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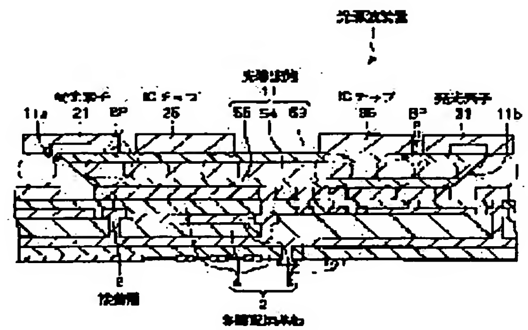
(54) OPTICAL WAVE GUIDE DEVICE AND ITS MANUFACTURE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an optical wave guide device having an optical waveguide warranting a high optical propagation characteristic regardless of a kind of a support pedestal and its manufacture.
SOLUTION: This optical wave guide device is provided with a multilayer wiring substrate 2, an optical waveguide 11, a light receiving element 21, IC chips 25, 35 and a light emitting element 31 arranged on the multilayer wiring substrate 2. Since the optical waveguide 11 is formed on a flat transparent substrate, and is transferred onto the multilayer wiring substrate 2, it has an advantage such as a less optical propagative loss. At this time, a signal to be transmitted at high speed is high speed transmitted as an optical signal, and the signal allowed to be transmitted at a relatively low speed is transmitted as an electric signal. Thus, the propagative delay of the signal becoming a problem in the case of transmitting only by the electric signal is dissolved, and the danger receiving an effect of an electromagnetic noise is reduced.



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* NOTICES *

CLAIMS

[Claim(s)]

[Claim 1] Photoconductive wave equipment characterized by having a substrate and the optical waveguide which arranges and fixed on said substrate while being beforehand formed separately so that a lightwave signal could spread the interior.

[Claim 2] Photoconductive wave equipment according to claim 1 characterized by forming electric wiring in said substrate.

[Claim 3] Furthermore, photoconductive wave equipment according to claim 1 characterized by having at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal into an electrical signal on said substrate.

[Claim 4] Furthermore, photoconductive wave equipment according to claim 3 characterized by having an integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting device or said photo detector on said substrate.

[Claim 5] For said substrate, said optical waveguide is photoconductive wave equipment according to claim 1 characterized by being formed on other different substrates and imprinting on said substrate from a substrate besides the above.

[Claim 6] Said optical waveguide is photoconductive wave equipment according to claim 1 characterized by having the light reflex section which has either [at least] the function which an end is made to reflect the lightwave signal from the outside, and is introduced into it in said optical waveguide at least, or the function which is made to reflect the lightwave signal which has spread the inside of said optical waveguide, and is derived out of said optical waveguide.

[Claim 7] It is photoconductive wave equipment according to claim 6 with which said light reflex section is characterized by the thing of said core layer prepared in the end at least while said optical waveguide is constituted including a core layer and a cladding layer.

[Claim 8] Furthermore, at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal on said substrate into an electrical signal. While having an integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting device or said photo detector, said optical waveguide Photoconductive wave equipment according to claim 2 characterized by having had the light reflex section for performing the input or output of a lightwave signal at the end at least, and having pasted said substrate through a glue line.

[Claim 9] Electric wiring of said substrate is photoconductive wave equipment according to claim 8 characterized by being for said light emitting device or said photo detector reaching on the other hand at least, and supplying a power source to said integrated circuit.

[Claim 10] Electric wiring of said substrate is photoconductive wave equipment according to claim 8 characterized by being for combining electrically at least one side and said integrated circuit of said light emitting device or said photo detector.

[Claim 11] Said substrate is photoconductive wave equipment according to claim 8 characterized by being the multilayer-interconnection substrate with which the laminating of two or more electric wiring layers was carried out through the insulator.

[Claim 12] Said optical waveguide is photoconductive wave equipment according to claim 8

characterized by being constituted including the 1st cladding layer formed on said substrate, the core layer by which the laminating was carried out on this 1st cladding layer, and the 2nd cladding layer by which the laminating was carried out on this core layer.

[Claim 13] Said 1st cladding layer is photoconductive wave equipment according to claim 12 characterized by serving as said glue line.

[Claim 14] Said glue line is photoconductive wave equipment according to claim 8 characterized by consisting of a photo-setting resin.

[Claim 15] Said glue line is photoconductive wave equipment according to claim 8 characterized by consisting of thermosetting resin.

[Claim 16] It is photoconductive wave equipment according to claim 8 characterized by for said light emitting device or a photo detector reaching on the other hand at least, and said integrated circuit being connected to electric wiring of said substrate by the connection electrode.

[Claim 17] Said connection electrode is photoconductive wave equipment according to claim 16 characterized by carrying out coating of the solder to the spherule which consists of a conductive ingredient.

[Claim 18] Said connection electrode is photoconductive wave equipment according to claim 16 characterized by consisting of solder which uses lead (Pb) and tin (Sn) as a principal component.

[Claim 19] Said optical waveguide is photoconductive wave equipment according to claim 8 which transmits a transmission signal at the 1st rate and is characterized by electric wiring of said substrate being what transmits a transmission signal at the 2nd rate smaller than said 1st rate.

[Claim 20] At least one of said light emitting device, a photo detector, or the integrated circuits is photoconductive wave equipment according to claim 8 characterized by being arranged on said substrate as a spacer which intervenes said optical waveguide between said substrates.

[Claim 21] Said light reflex section is photoconductive wave equipment according to claim 8 characterized by having either [at least] the function which is made to reflect the lightwave signal from the outside and is introduced in said optical waveguide, or the function which is made to reflect the lightwave signal which has spread the inside of said optical waveguide, and is derived out of said optical waveguide while being constituted by the inclined plane of said optical waveguide formed in the end side at least.

[Claim 22] Said inclined plane is photoconductive wave equipment according to claim 21 characterized by inclining in 45 abbreviation to the optical propagation direction in said optical waveguide.

[Claim 23] The insulator of said multilayer-interconnection substrate is photoconductive wave equipment according to claim 11 characterized by consisting of an inorganic material containing at least one sort in the group which consists of an alumina (aluminum 2O3), a glass ceramic, aluminum night RAIDO (AlN), and a mullite.

[Claim 24] The insulator of said multilayer-interconnection substrate is photoconductive wave equipment according to claim 11 characterized by consisting of an organic material containing at least one sort in the group which consists of a glass epoxy resin, polyimide, BT resin, PPE (polyphenyl ether) resin, phenol resin, and polyolefin resin.

[Claim 25] The manufacture approach of the photoconductive wave equipment characterized by including the process which makes the process which forms optical waveguide by using the 1st substrate as a support base, and said optical waveguide supported by said 1st substrate and the 2nd substrate fix, and the process which imprints said optical waveguide to said 2nd substrate by removing said 1st substrate.

[Claim 26] The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by performing the process which makes said optical waveguide and 2nd substrate fix using adhesives.

[Claim 27] The manufacture approach of the photoconductive wave equipment according to claim 26 characterized by using a photo-setting resin as said adhesives.

[Claim 28] The manufacture approach of the photoconductive wave equipment according to claim 27 characterized by stiffening said photo-setting resin by irradiating light through this 1st substrate while using the substrate which consists of an ingredient of light transmission nature

as said 1st substrate.

[Claim 29] The process which fixes the process which forms said optical waveguide, and said optical waveguide and 2nd substrate The process which forms a core layer, and the process which forms the resin layer which turns into a cladding layer as surrounds this core layer, The process which pastes up said optical waveguide supported by said 1st substrate, and said 2nd substrate, using said resin layer in the condition of not hardening, as said adhesives, The manufacture approach of the photoconductive wave equipment according to claim 26 characterized by including the process which makes fixing with said optical waveguide and said 2nd substrate complete at the same time it stiffens said resin layer and forms said cladding layer.

[Claim 30] While the process which forms said optical waveguide includes the process which forms the substrate detached core which makes it possible to separate said 1st substrate from said optical waveguide in a back process between said 1st substrate and said optical waveguides The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by removing said 1st substrate by removing said substrate detached core in the process which imprints said optical waveguide to the 2nd substrate.

[Claim 31] The manufacture approach of the photoconductive wave equipment according to claim 30 characterized by forming said substrate detached core with a silicon dioxide (SiO_2).

[Claim 32] The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by removing this by melting said 1st substrate in the process which imprints said optical waveguide to the 2nd substrate while using the substrate which consists of an ingredient which can dissolve with a predetermined solution as said 1st substrate.

[Claim 33] It is the manufacture approach of the photoconductive wave equipment according to claim 32 which said solution is a hydrogen fluoride (HF) solution below 5 volume %, and is characterized by the ingredient in which said dissolution is possible being photosensitive glass.

[Claim 34] The process which forms optical waveguide on said 1st substrate The process which makes said optical waveguide and 2nd substrate fix including the process which forms two or more optical waveguides estranged mutually The process which pastes up said 2nd substrate on said optical waveguide through the glue line which consists of a photo-setting resin, The process which light is irradiated through said 1st substrate at said glue line, and only the field corresponding to said optical waveguide is exposed [process] alternatively, and stiffens it among this glue line, The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by including the process which removes the photo-setting resin which is not hardened on said 2nd substrate.

[Claim 35] The manufacture approach of the photoconductive wave equipment according to claim 34 characterized by performing alternative exposure for this light-shielding film as a mask before the process which pastes up the 2nd substrate on said optical waveguide including the process which forms a light-shielding film in fields other than the field in which said optical waveguide on said 1st substrate is formed further, and the side face of each of said optical waveguide.

[Claim 36] The process which forms said light-shielding film is the manufacture approach of the photoconductive wave equipment according to claim 35 characterized by to include said 2nd substrate of said optical waveguide, the process which forms stratum disjunctum in the field of the side which fixes, the process which forms a light-shielding film in said 1st substrate, said optical waveguide, and the whole exposure of said stratum disjunctum, and the process which removes alternatively said light-shielding film which is in contact with said stratum disjunctum by removing said stratum disjunctum.

[Claim 37] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 25 characterized by including the process which forms at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal into an electrical signal on said 2nd substrate.

[Claim 38] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 37 characterized by including the process which forms the integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting

device or said photo detector on said 2nd substrate.

[Claim 39] Said 2nd substrate is the manufacture approach of the photoconductive wave equipment according to claim 25 characterized by being the electric wiring substrate with which electric wiring was formed.

[Claim 40] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 39 characterized by including the process which forms at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal into an electrical signal on said 2nd substrate, and the process which forms the integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting device or said photo detector on said 2nd substrate.

[Claim 41] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 40 characterized by including the process which said light emitting device or said photo detector reaches on the other hand at least, and closes said integrated circuit with a closure resin ingredient.

[Claim 42] The process which forms optical waveguide by using said 1st substrate as a support base is the manufacture approach of the photoconductive wave equipment according to claim 40 characterized by including the process which forms a disengageable substrate detached core for said the 1st substrate and said optical waveguide on said 1st substrate, the process which forms optical waveguide on said substrate detached core, and the process of said optical waveguide which forms an inclined plane in the end section at least.

[Claim 43] The process which forms said optical waveguide is the manufacture approach of the photoconductive wave equipment according to claim 42 characterized by including the process which forms the 1st cladding layer on said substrate detached core, the process which forms a core layer on said 1st cladding layer, and the process which forms the 2nd cladding layer on said core layer.

[Claim 44] The manufacture approach of the photoconductive wave equipment according to claim 40 characterized by using the multilayer-interconnection substrate which contains at least one sort of inorganic materials of the groups which consist of an alumina (aluminum 2O3), a glass ceramic, aluminum night RAIDO (AlN), and a mullite as said 2nd substrate.

[Claim 45] The manufacture approach of the photoconductive wave equipment according to claim 40 characterized by using the multilayer-interconnection substrate which contains at least one sort of organic materials of the groups which consist of a glass epoxy resin, polyimide, BT resin, PPE (polyphenyl ether) resin, phenol resin, and polyolefin resin as said 2nd substrate.

[Claim 46]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] Photoconductive wave equipment characterized by having a substrate and the optical waveguide which arranges and fixed on said substrate while being beforehand formed separately so that a lightwave signal could spread the interior.
[Claim 2] Photoconductive wave equipment according to claim 1 characterized by forming electric wiring in said substrate.
[Claim 3] Furthermore, photoconductive wave equipment according to claim 1 characterized by having at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal into an electrical signal on said substrate.
[Claim 4] Furthermore, photoconductive wave equipment according to claim 3 characterized by having an integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting device or said photo detector on said substrate.
[Claim 5] For said substrate, said optical waveguide is photoconductive wave equipment according to claim 1 characterized by being formed on other different substrates and imprinting on said substrate from a substrate besides the above.
[Claim 6] Said optical waveguide is photoconductive wave equipment according to claim 1 characterized by having the light reflex section which has either [at least] the function which an end is made to reflect the lightwave signal from the outside, and is introduced into it in said optical waveguide at least, or the function which is made to reflect the lightwave signal which has spread the inside of said optical waveguide, and is derived out of said optical waveguide.
[Claim 7] It is photoconductive wave equipment according to claim 6 with which said light reflex section is characterized by the thing of said core layer prepared in the end at least while said optical waveguide is constituted including a core layer and a cladding layer.
[Claim 8] Furthermore, at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal on said substrate into an electrical signal, While having an integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting device or said photo detector, said optical waveguide Photoconductive wave equipment according to claim 2 characterized by having had the light reflex section for performing the input or output of a lightwave signal at the end at least, and having pasted said substrate through a glue line.
[Claim 9] Electric wiring of said substrate is photoconductive wave equipment according to claim 8 characterized by being for said light emitting device or said photo detector reaching on the other hand at least, and supplying a power source to said integrated circuit.
[Claim 10] Electric wiring of said substrate is photoconductive wave equipment according to claim 8 characterized by being for combining electrically at least one side and said integrated circuit of said light emitting device or said photo detector.
[Claim 11] Said substrate is photoconductive wave equipment according to claim 8 characterized by being the multilayer-interconnection substrate with which the laminating of two or more electric wiring layers was carried out through the insulator.
[Claim 12] Said optical waveguide is photoconductive wave equipment according to claim 8

characterized by being constituted including the 1st cladding layer formed on said substrate, the core layer by which the laminating was carried out on this 1st cladding layer, and the 2nd cladding layer by which the laminating was carried out on this core layer.
[Claim 13] Said 1st cladding layer is photoconductive wave equipment according to claim 12 characterized by serving as said glue line.
[Claim 14] Said glue line is photoconductive wave equipment according to claim 8 characterized by consisting of a photo-setting resin.
[Claim 15] Said glue line is photoconductive wave equipment according to claim 8 characterized by consisting of thermosetting resin.
[Claim 16] It is photoconductive wave equipment according to claim 8 characterized by for said light emitting device or a photo detector reaching on the other hand at least, and said integrated circuit being connected to electric wiring of said substrate by the connection electrode.
[Claim 17] Said connection electrode is photoconductive wave equipment according to claim 16 characterized by carrying out coating of the solder to the spherule which consists of a conductive ingredient.
[Claim 18] Said connection electrode is photoconductive wave equipment according to claim 16 characterized by consisting of solder which uses lead (Pb) and tin (Sn) as a principal component.

[Claim 19] Said optical waveguide is photoconductive wave equipment according to claim 8 which transmits a transmission signal at the 1st rate and is characterized by electric wiring of said substrate being what transmits a transmission signal at the 2nd rate smaller than said 1st rate.
[Claim 20] At least one of said light emitting device, a photo detector, or the integrated circuits is photoconductive wave equipment according to claim 8 characterized by being arranged on said substrate as a spacer which intervenes said optical waveguide between said substrates.
[Claim 21] Said light reflex section is photoconductive wave equipment according to claim 8 characterized by having either [at least] the function which is made to reflect the lightwave signal from the outside and is introduced in said optical waveguide, or the function which is made to reflect the lightwave signal which has spread the inside of said optical waveguide, and is derived out of said optical waveguide while being constituted by the inclined plane of said optical waveguide formed in the end side at least.
[Claim 22] Said inclined plane is photoconductive wave equipment according to claim 21 characterized by inclining in 45 abbreviation to the optical propagation direction in said optical waveguide.
[Claim 23] The insulator of said multilayer-interconnection substrate is photoconductive wave equipment according to claim 11 characterized by consisting of an inorganic material containing at least one sort in the group which consists of an alumina (aluminum 2O3), a glass ceramic, aluminum night RAIDO (AIN), and a mullite.
[Claim 24] The insulator of said multilayer-interconnection substrate is photoconductive wave equipment according to claim 11 characterized by consisting of an organic material containing at least one sort in the group which consists of a glass epoxy resin, polyimide, BT resin, PPE (polyphenyl ether) resin, phenol resin, and polyolefin resin.
[Claim 25] The manufacture approach of the photoconductive wave equipment characterized by including the process which makes the process which forms optical waveguide by using the 1st substrate as a support base, and said optical waveguide supported by said 1st substrate and the 2nd substrate fix, and the process which imprints said optical waveguide to said 2nd substrate by removing said 1st substrate.
[Claim 26] The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by performing the process which makes said optical waveguide and 2nd substrate fix using adhesives.
[Claim 27] The manufacture approach of the photoconductive wave equipment according to claim 26 characterized by using a photo-setting resin as said adhesives.
[Claim 28] The manufacture approach of the photoconductive wave equipment according to claim 27 characterized by stiffening said photo-setting resin by irradiating light through this 1st substrate while using the substrate which consists of an ingredient of light transmission nature

as said 1st substrate.
[Claim 29] The process which fixes the process which forms said optical waveguide, and said optical waveguide and 2nd substrate The process which forms a core layer, and the process which forms the resin layer which turns into a cladding layer as surrounds this core layer, The process which pastes up said optical waveguide supported by said 1st substrate, and said 2nd substrate, using said resin layer in the condition of not hardening, as said adhesives, The manufacture approach of the photoconductive wave equipment according to claim 26 characterized by including the process which makes fixing with said optical waveguide and said 2nd substrate complete at the same time it stiffens said resin layer and forms said cladding layer.
[Claim 30] While the process which forms said optical waveguide includes the process which forms the substrate detached core which makes it possible to separate said 1st substrate from said optical waveguide in a back process between said 1st substrate and said optical waveguides The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by removing said 1st substrate by removing said substrate detached core in the process which imprints said optical waveguide to the 2nd substrate.
[Claim 31] The manufacture approach of the photoconductive wave equipment according to claim 30 characterized by forming said substrate detached core with a silicon dioxide (SiO_2).
[Claim 32] The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by removing this by melting said 1st substrate in the process which imprints said optical waveguide to the 2nd substrate while using the substrate which consists of an ingredient which can dissolve with a predetermined solution as said 1st substrate.
[Claim 33] It is the manufacture approach of the photoconductive wave equipment according to claim 32 which said solution is a hydrogen fluoride (HF) solution below 5 volume %, and is characterized by the ingredient in which said dissolution is possible being photosensitive glass.
[Claim 34] The process which forms optical waveguide on said 1st substrate The process which makes said optical waveguide and 2nd substrate fix including the process which forms two or more optical waveguides estranged mutually The process which pastes up said 2nd substrate on said optical waveguide through the glue line which consists of a photo-setting resin, The process which light is irradiated through said 1st substrate at said glue line, and only the field corresponding to said optical waveguide is exposed [process] alternatively, and stiffens it among this glue line, The manufacture approach of the photoconductive wave equipment according to claim 25 characterized by including the process which removes the photo-setting resin which is not hardened on said 2nd substrate.
[Claim 35] The manufacture approach of the photoconductive wave equipment according to claim 34 characterized by performing alternative exposure for this light-shielding film as a mask before the process which pastes up the 2nd substrate on said optical waveguide including the process which forms a light-shielding film in fields other than the field in which said optical waveguide on said 1st substrate is formed further, and the side face of each of said optical waveguide.
[Claim 36] The process which forms said light-shielding film is the manufacture approach of the photoconductive wave equipment according to claim 35 characterized by to include said 2nd substrate of said optical waveguide, the process which forms stratum disjunctum in the field of the side which fixes, the process which forms a light-shielding film in said 1st substrate, said optical waveguide, and the whole exposure of said stratum disjunctum, and the process which removes alternatively said light-shielding film which is in contact with said stratum disjunctum by removing said stratum disjunctum.
[Claim 37] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 25 characterized by including the process which forms at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal into an electrical signal on said 2nd substrate.
[Claim 38] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 37 characterized by including the process which forms the integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting

device or said photo detector on said 2nd substrate.
[Claim 39] Said 2nd substrate is the manufacture approach of the photoconductive wave equipment according to claim 25 characterized by being the electric wiring substrate with which electric wiring was formed.
[Claim 40] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 39 characterized by including the process which forms at least one side of the photo detector for changing the light emitting device or lightwave signal for changing an electrical signal into a lightwave signal into an electrical signal on said 2nd substrate, and the process which forms the integrated circuit for delivering and receiving an electrical signal between [one / at least] said light emitting device or said photo detector on said 2nd substrate.
[Claim 41] Furthermore, the manufacture approach of the photoconductive wave equipment according to claim 40 characterized by including the process which said light emitting device or said photo detector reaches on the other hand at least, and closes said integrated circuit with a closure resin ingredient.
[Claim 42] The process which forms optical waveguide by using said 1st substrate as a support base is the manufacture approach of the photoconductive wave equipment according to claim 40 characterized by including the process which forms a disengageable substrate detached core for said the 1st substrate and said optical waveguide on said 1st substrate, the process which forms optical waveguide on said substrate detached core, and the process of said optical waveguide which forms an inclined plane in the end section at least.
[Claim 43] The process which forms said optical waveguide is the manufacture approach of the photoconductive wave equipment according to claim 42 characterized by including the process which forms the 1st cladding layer on said substrate detached core, the process which forms a core layer on said 1st cladding layer, and the process which forms the 2nd cladding layer on said core layer.
[Claim 44] The manufacture approach of the photoconductive wave equipment according to claim 40 characterized by using the multilayer-interconnection substrate which contains at least one sort of inorganic materials of the groups which consist of an alumina (aluminum 2O3), a glass ceramic, aluminum night RAIDO (AIN), and a mullite as said 2nd substrate.
[Claim 45] The manufacture approach of the photoconductive wave equipment according to claim 40 characterized by using the multilayer-interconnection substrate which contains at least one sort of organic materials of the groups which consist of a glass epoxy resin, polyimide, BT resin, PPE (polyphenyl ether) resin, phenol resin, and polyolefin resin as said 2nd substrate.
[Claim 46] Said 2nd substrate is the manufacture approach of the photoconductive wave equipment according to claim 40 characterized by consisting of printing substrates with which the electric circuit pattern was printed while being formed in one [at least] field of a core substrate and this core substrate.
[Claim 47] The manufacture approach of the photoconductive wave equipment according to claim 43 characterized by using what has a rate of optical refraction smaller than the ingredient which forms said core layer as an ingredient which forms said 1st and 2nd cladding layers.
[Claim 48] The manufacture approach of the photoconductive wave equipment according to claim 43 characterized by using what contains at least one sort in the group which consists of polyimide, an epoxy resin, acrylic resin, polyolefin resin, and synthetic rubber as a principal component as an ingredient which forms said 1st and 2nd cladding layers.
[Claim 49] The manufacture approach of the photoconductive wave equipment according to claim 42 characterized by using diacid-ized silicon (SiO_2) as an ingredient which forms said substrate detached core.
[Claim 50] The manufacture approach of the photoconductive wave equipment according to claim 42 characterized by using the metallic material which can be etched as an ingredient which forms said substrate detached core.
[Claim 51] The process of said optical waveguide which forms an inclined plane in the end section at least The process which applies a photoresist on said optical waveguide, performs exposure and a development to this photoresist, and forms a desired photoresist pattern, The

process which makes the edge field of said photoresist pattern incline, and said photoresist pattern are used as a mask. Anisotropic etching of the part exposed from the edge field of said photoresist pattern of said optical waveguide is carried out. The manufacture approach of the photoconductive wave equipment according to claim 42 characterized by including the process which makes the edge of said optical waveguide a taper-like inclined plane, and the process which removes said photoresist pattern.

[Claim 52] The process of said optical waveguide which forms an inclined plane in the end section at least The process which carries out vacuum evaporationo formation of the metal membrane on said optical waveguide, and the process which applies a photoresist, performs exposure and a development to this photoresist, and forms a desired photoresist pattern on said metal membrane, The process which etches said metal membrane by using said photoresist pattern as a mask, and forms said metal membrane in a desired pattern, The process which forms said inclined plane by irradiating a laser beam from a predetermined include angle to the predetermined field of said optical waveguide layer by using said metal membrane as a mask, and cutting said optical waveguide, The manufacture approach of the photoconductive wave equipment according to claim 42 characterized by including the process which removes said metal membrane by etching and washes the whole workpiece.

[Claim 53] The process of said optical waveguide which forms an inclined plane in the end section at least By heating the heating tool which has an inclined plane in a point, carrying out the closet of the point of this heating tool to said optical waveguide, and fusing optical waveguide The manufacture approach of the photoconductive wave equipment according to claim 42 characterized by including the process which forms said inclined plane in said optical waveguide, and the process which removes the processing waste produced in the fusion zone of said optical waveguide by polish processing after removing said heating tool.

[Claim 54] The process of said optical waveguide which forms an inclined plane in the end section at least is the manufacture approach of the photoconductive wave equipment according to claim 42 characterized by including the process which cuts said 1st substrate at an angle of predetermined, and the process which grinds the end face formed of said cutting of said 1st substrate, and makes the edge of said optical waveguide an inclined plane.

[Claim 55] While using the substrate which consists of an ingredient of the light transmission nature which makes light penetrate as said 1st substrate, the process which makes said optical waveguide fix the 2nd substrate The process which forms the glue line which becomes a position on said 2nd substrate from the photo-setting resin hardened by the exposure of light. The manufacture approach of the photoconductive wave equipment according to claim 40 characterized by including the process which sticks the glue line of said 2nd substrate to the optical waveguide formed in said 1st substrate, and the process which light is irradiated [process] towards said 2nd substrate from the rear face of said 1st substrate, and stiffens said glue fine.

[Claim 56] The process which makes said optical waveguide fix the 2nd substrate The process which forms the glue line which becomes a position on said 2nd substrate from thermosetting resin, The manufacture approach of the photoconductive wave equipment according to claim 40 characterized by including the process which sticks the glue line of said 2nd substrate to the optical waveguide formed in said 1st substrate, and the process which said 1st substrate and the 2nd whole substrate are heated [process], and stiffens said glue line.

[Claim 57] The manufacture approach of the photoconductive wave equipment according to claim 42 characterized by supplying a solvent between said 1st pasted-up substrate and said 2nd substrate in the process which imprints said optical waveguide to said 2nd substrate by removing said 1st substrate, removing said substrate detached core, and making it separate said 1st substrate from said optical waveguide.

[Claim 58] The manufacture approach of the photoconductive wave equipment according to claim 42 characterized by supplying a solvent between said 1st pasted-up substrate and said 2nd substrate, and making it divide the interface of said substrate detached core and said optical waveguide into it in the process which imprints said optical waveguide to said 2nd substrate by removing said 1st substrate.

[Claim 59] It is the manufacture approach of the photoconductive wave equipment according to claim 40 which said light emitting device or a photo detector reaches on the other hand at least, and is characterized by having the connection electrode, for said light emitting device or a photo detector reaching on the other hand at least in the process which forms the process which forms either [at least] said light emitting device or a photo detector, and said integrated circuit, and said integrated circuit mounting said integrated circuit in said 2nd substrate by the flip-chip-bonding method using said connection electrode.

[Claim 60] The manufacture approach of the photoconductive wave equipment according to claim 59 characterized by using said optical waveguide in the process which forms the process which forms either [at least] said light emitting device or a photo detector, and said integrated circuit as a spacer which said light emitting device or a photo detector reaches on the other hand at least, and intervenes between said integrated circuit and said 2nd substrate.

[Claim 61] on the other hand, there is said light emitting device or a photo detector at least about the spherical section formed at the tip of a metal thin line — it is — the manufacture approach of the photoconductive wave equipment according to claim 59 characterized by forming said connection electrode by cutting it as between said spherical sections and said metal thin lines is pulled apart after being stuck to the electrode of said integrated circuit by pressure.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to photoconductive wave equipment equipped with the optical waveguide to which a lightwave signal spreads the interior, and its manufacture approach, especially, is used for optical connection of transceiver modules for optical transmissions, such as transmission of the lightwave signal in digital disposal circuits, such as a ultra high-speed digital disposal circuit and a parallel connected type digital digital disposal circuit, and optical communication, an optical link or an optical Fiber Channel, and relates to suitable photoconductive wave equipment and its manufacture approach.
[0002]
[Description of the Prior Art] The motion which transmits and receives all media through an information communication network is progressing that the throughput of information processors, such as a wire communication technique used for the radio technique used for a cellular phone etc., ISDN (Integrated Services Digital Network), etc. or a personal computer (Personal Computer-C), improved by leaps and bounds in recent years, by having digitized AV (Audiovisual) device, etc. Moreover, the Internet is begun and information communication networks, such as LAN (Local Area Network) and WAN (Wide Area Network), are spreading [business use and personal]. From these things, home electronics and an AV equipment constitute a network from domestic centering on PC, and it will be thought in the future that the environment where information is freely exchanged with means of signal transduction, such as the telephone line, CATV (Cable Television or Community Antenna Television), terrestrial television, or satellite broadcasting service/satellite communication, is realized.
[0003] in order to exchange freely the image data dealt with at a quick rate called several M-about tenMbps(es) by such means of signal transduction, an about [10M-1Gbps] information transmission rate is desired. Optical communication and a transmission technique can realize such an information transmission rate. For example, in the so-called trunk system communication network exceeding 10km - 100km, optical communication and a transmission technique have spread widely from viewpoints, such as the low loss nature, economical efficiency, etc., like the optical cable laid by the seabed.
[0004] on the other hand -- between the chips between the boards in a device, or in a board etc. -- as a means of signal transduction between short distance, a wire communication and transmission means, such as a TSUISUTEDDO pair cable and a coaxial cable, are mainly used comparatively. Although recent years come and the spread of the techniques using optical transmissions, such as an optical Fiber Channel and an optical data link, has started, optical communication and a transmission means have not resulted in spread to the extent that a wire communication and a transmission means are replaced in present. The problem of the cost pair effectiveness is mentioned as this reason. In order to maintain the engine performance (for example, transmission speed and the transmission quality) of optical communication, specifically, points, like that that a precise alignment technique is required, the cure against leak light, consideration of electromagnetic interference, or the cure against a noise etc. is required between the light emitting device and photo detector which constitute optical-communication

equipment, and an optical fiber, and equipment becomes intricately and expensive as a result are mentioned.
[0005] On the other hand, by advance of the technique in IC (Integrated Circuit; integrated circuit) or LSI (Large Scale Integration; large-scale integrated circuit), those working speeds and accumulation scales improve, for example, high-performance-izing of a microprocessor and large capacity-ization of a memory chip are attained quickly. Moreover, the amount of information which PC connected by the network deals with is increasing quickly. Therefore, the technical problem that it must correspond to the rise of the frequency of a signal-processing clock, the rise of whenever [juxtaposition], improvement in the speed of the access time to memory, etc. also exists. In the bottom of such a situation, improvement in the speed of a working speed is attained inside the semiconductor chip by detailed-izing of a semiconductor chip, contraction of the gate length of the transistor accompanying it, improvement in drive capacity, etc. However, in the access circuit to memory, the processor of a multi-MPU (Microprocessor Unit) configuration, etc., the parasitic capacitance component of the part which is needed at the time of mounting of the package of a semiconductor device etc. is large, and high-speed signal-transmission actuation is difficult in electric wiring which connects with the exterior of a semiconductor chip. Moreover, when it comes to the cause of current change of the letter of a spike, or electrical-potential-difference change, both impression of the high speed signal to electric wiring causes electromagnetic-compatibility noises, such as EMI (Electromagnetic Interference)/EMC (Electromagnetic Compatibility), a reflective noise, and a cross talk noise.
[0006] Then, also in short-distance signal-transmission paths, such as between the semiconductor chips on a wiring substrate, in order to transmit a high speed signal, it is thought desirable performing transmission by light, especially to use the optical transmission and communication system which made optical waveguide the transmission line. Since the signal delay by CR (C: electrostatic-capacity [of wiring], resistance of Rwiring) time constant of wiring can be canceled and the effect of an electromagnetic noise can be avoided when light performs a signal transmission, transfer of a high-speed signal is attained. Therefore, while maintaining the communication link engine performance of optical communication and transmission to the communication link engine performance and EQC of a wire communication and transmission, it is necessary to spread the optical communication and the transmission system between short distance also in the field of the device for general need persons by realizing reduction of cost.
[0007] In order to maintain the communication link engine performance of optical communication and transmission to the communication link engine performance and EQC of a wire communication and transmission, it is required that the optical transmission loss of optical waveguide should be small. There is an ingredient of a quartz system as a small ingredient of optical transmission loss which fulfills this condition. As the quartz is already proved by the optical fiber, light transmission nature is very good, and when optical waveguide is produced with a quartz, low loss-ization of 0.1 or less dB/cm is attained.
[0008] Drawing 32 expresses the example of 1 configuration of conventional photoconductive wave equipment (refer to JP,62-204208,A). This photoconductive wave equipment is equipped with the optical waveguide 502 and LSI504 which consist of a quartz on the flat silicon substrate 501 in which the thin film multilayer interconnection 505 with which between each wiring was insulated by the insulating layer 506 was formed. Moreover, above each edge field of optical waveguide 502, a photo detector 503 and a light emitting device (not shown) are formed, respectively, and it connects with LSI504 arranged in the near electrically, respectively. With this photoconductive wave equipment, the interior of optical waveguide 502 is spread, it is reflected by end-face 502a, and the lightwave signal which carried out outgoing radiation from the light emitting device which is not illustrated carries out incidence to a photo detector 503.
[0009] After forming optical waveguide 502 as the manufacture approach of photoconductive wave equipment of having such a configuration, on the silicon substrate 501 in which the thin film multilayer interconnection 505 was formed, it is processed so that it may become 45 degrees of abbreviation to the front face of a silicon substrate 501 about end-face 502a of optical waveguide 502 by anisotropic etching, such as RIE (Reactive Ion Etching; reactive ion

etching), and the method of mounting a photo detector 503, a light emitting device, and LSI504 on a silicon substrate 501 is learned further.
[0010]
[Problem(s) to be Solved by the Invention] However, by the manufacture approach of the photoconductive wave equipment mentioned above, since he was trying to form the optical waveguide 502 which consists of a quartz on a silicon substrate 501, the thin film technology needed to be used as a formation technique of optical waveguide 502. While formation of the optical waveguide 502 using a thin film technology is excellent in dimensional accuracy, disadvantageous profit that formation and processing of the film with a thickness of several micrometers or more are difficult exists.
[0011] Moreover, even if it is able to transmit a signal to a high speed by light, electric wiring (electrical signal) still needs to perform transmission of an electric power supply, the control signal of low-speed various kinds comparatively, etc. Therefore, although it was indispensable to have formed the thin film multilayer interconnection 505 as electric wiring on a silicon substrate 501, when this electric wiring formation field became usual wiring substrate size (dozens of cm angle) and module size (several cm angle), cost started too much and the problem of being scarce was in implementability.
[0012] In order to solve this problem, it is possible to form optical waveguide on the printed wiring substrate in which an electrical part can be carried. However, the thick film of the metal formed for example, by the galvanizing method etc. is arranged in the front face of the wiring substrate made to manufacture according to such a thick-film process, and irregularity is large. Therefore, when optical waveguide was formed on such a printed wiring substrate, the shape of toothing on the front face of a substrate affected the configuration of optical waveguide, and there was a problem of leading to increase of the optical transmission loss of optical waveguide or the fall of dimensional accuracy.
[0013] Furthermore, since the process which dips the whole substrate in an acid and an alkali solution, an organic solvent, etc. was needed when forming optical waveguide on a wiring substrate, and performing wet etching, washing, etc., there was a problem that there was a possibility of doing damage to a substrate. Moreover, a possibility of doing damage is also in a substrate at the time of dry etching and elevated-temperature heat treatment. Therefore, it is difficult to use the electric wiring substrate by the thick-film process as a substrate, for example, the expensive substrate which has properties, such as high thermal resistance, needed to be used.
[0014] This invention was made in view of this trouble, and the 1st purpose is in offering the photoconductive wave equipment which has the optical waveguide which can collateralize an optical high propagation property, and its manufacture approach irrespective of the class of support base.
[0015] The 2nd purpose of this invention is to offer the photoconductive wave equipment which can attain reduction-ization of a manufacturing cost, and its manufacture approach while optical waveguide is formed cheaply.
[0016] moreover -- while the 3rd purpose of this invention enables transmission of the signal of the further high speed which was difficult to realize only with electric wiring -- a transmission signal -- -proof -- electromagnetism -- it is in offering the photoconductive wave equipment which can raise noise nature, and its manufacture approach.
[0017]
[Means for Solving the Problem] The photoconductive wave equipment by this invention is equipped with a substrate and the optical waveguide which has been arranged on a substrate and fixed while being beforehand formed separately so that a lightwave signal could spread the interior.
[0018] The manufacture approach of the photoconductive wave equipment by this invention includes the process which makes the process which forms optical waveguide by using the 1st substrate as a support base, the optical waveguide supported by the 1st substrate, and the 2nd substrate fix, and the process which imprints optical waveguide to the 2nd substrate by removing the 1st substrate.

[0019] With the photoconductive wave equipment by this invention, the optical waveguide formed separately beforehand is arranged on the substrate, and a lightwave signal spreads the interior of this optical waveguide.
[0020] By the manufacture approach of the photoconductive wave equipment by this invention, after the optical waveguide and the 2nd substrate which were formed as a support base fix the 1st substrate, optical waveguide is imprinted by the 2nd substrate by removing the 1st substrate.

[0021]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail with reference to a drawing.
[0022] (Gestalt of the 1st operation) With reference to drawing 1 , the configuration of the photoconductive wave equipment concerning the gestalt of operation of the 1st of this invention is explained first.
[0023] Drawing 1 expresses the cross-section configuration of the photoconductive wave equipment 1 concerning the gestalt of this operation. This photoconductive wave equipment 1 is equipped with the multilayer-interconnection substrate 2, the optical waveguide 11 pasted up on the multilayer-interconnection substrate 2 through the glue line 6, and the photo detector 21, the IC chips 25 and 35 and light emitting device 31 which inserted in between by having used optical waveguide 11 as the spacer, and were mounted on the multilayer-interconnection substrate 2. Here, the multilayer-interconnection substrate 2 supports one example of the "substrate" of this invention, and the "2nd substrate." Moreover, the IC chips 25 and 35 support one example of the "integrated circuit" of this invention.
[0024] The multilayer-interconnection substrate 2 is an electric wiring substrate with which the laminating of two or more electric wiring 3 was carried out through the insulator 4. For example, a low-speed control signal is delivered and received between the IC chips 25 and 35, a photo detector 21, and a light emitting device 31, or electric wiring 3 has the function which delivers and receives a signal between the exteriors while having the function which supplies power to the IC chips 25 and 35, a photo detector 21, and a light emitting device 31. That is, electric wiring 3 is pattern wiring for mounting for mounting a photo detector 21, a light emitting device 31, and the IC chips 25 and 35 on the multilayer-interconnection substrate 2. Wiring for combining the IC chips 25 and 35, a photo detector 21, and light emitting device 31 including wiring for supplying the various power-source circuit patterns and the signal for control which specifically include the ground line for supplying power in a photo detector 21, a light emitting device 31, and the IC chips 25 and 35 etc. is formed.
[0025] As a multilayer-interconnection substrate 2, the ceramic multilayer-interconnection substrate with which an insulator 4 consists of inorganic materials, such as an alumina (aluminum 2O3), a low-temperature baking glass ceramic, a glass ceramic, aluminum night RAIDO (AlN), and a mullite, is used, for example. Moreover, the glass epoxy multilayer-interconnection substrate with which an insulator 4 consists of glass epoxy resins, such as FR-4, Made high density pattern formation possible with the photolithography technique which used for example, the photosensitive epoxy resin etc. on the usual glass epoxy wiring substrate. The so-called build up multilayer-interconnection substrate, the flexible multilayer-interconnection substrate which used the polyimide film etc. for the insulator 4, Or the multilayer-interconnection substrate using organic materials, such as BT resin, PPE (polyphenyl ether) resin, phenol resin, and polyolefin resin (for example, Du Pont Teflon (trademark registration)), may be used. The so-called printed-circuit board with which it, in addition to this, comes to arrange the printing substrate with which the electric circuit pattern was printed by high density on the core substrate which consists of dielectric materials can also be used.
[0026] The glue line 6 intervenes between optical waveguide 11 and the multilayer-interconnection substrate 2, for example, is constituted by a photo-setting resin or thermosetting resin, such as a glass epoxy resin. Moreover, the thickness is about 10 micrometers. This glue line 6 has also played the role which carries out flattening of the unevenness of a multilayer-interconnection substrate front face other than a role on which optical waveguide 11 and the multilayer-interconnection substrate 2 are pasted up.

[0027] Optical waveguide 11 is constituted by the core layer 54, and the up cladding layer 53 and the lower cladding layer 55 which were formed as surrounded the core layer 54. This optical waveguide 11 has the front face of the multilayer-interconnection substrate 2, and the inclined planes [as / whose exterior angles to make are acute angles (45 degrees of abbreviation / Here /)] 11a and 11b to both ends. In addition, the front face of the multilayer-interconnection substrate 2 of optical waveguide 11 and the exterior angle to make mean the thing of the exterior angle of this graphic form at the time of thinking that it is the graphic form which the cross section which met in the optical propagation direction of optical waveguide 11 closed. Here, the up cladding layer 53 supports to one example of the "1st cladding layer" of this invention, and the lower cladding layer 55 supports one example of the "2nd cladding layer" of this invention, respectively. Moreover, inclined planes 11a and 11b support one example of the "light reflex section" of this invention.
[0028] Inclined planes 11a and 11b have the function derived in the direction which is made to reflect the lightwave signal which has spread the inside of optical waveguide 11, and intersects perpendicularly with the principal plane of the multilayer-interconnection substrate 2 while the front face of the multilayer-interconnection substrate 2 and the exterior angle to make are 45 degrees of abbreviation as mentioned above, and they reflect the lightwave signal which carries out incidence in the direction which intersects perpendicularly with the principal plane of the multilayer-interconnection substrate 2 from the exterior of optical waveguide 11 and introducing them in optical waveguide 11.
[0029] The up cladding layer 53 and the lower cladding layer 55 are constituted by the epoxy resin which uses as a principal member the bisphenol whose refractive index is about 1.52, and thickness is 20 micrometers. Moreover, the core layer 54 is constituted by an ingredient with a bigger refractive index than the component of the up cladding layer 53 and the lower cladding layer 55, for example, the epoxy resin whose refractive index is about 1.54. The thickness of a core layer 54 is 20 micrometers, and width of face is 60 micrometers. In addition, as long as the up cladding layer 53, a core layer 54, and the lower cladding layer 55 fulfill the conditions that the refractive index of a core layer 54 is larger than the refractive index of the up cladding layer 53 and the lower cladding layer 55, they may be constituted by polyolefin resin, such as acrylic resin, such as other ingredients, for example, polyimide, and polymethylmethacrylate (PMMA:Polymethyl Methacrylate), polyethylene, and polystyrene, or synthetic rubber.
[0030] A photo detector 21 changes into an electrical signal the lightwave signal by which incidence is carried out to the plane of incidence from optical waveguide 11, and outputs it to the electric wiring 3 formed in the multilayer-interconnection substrate 2, and a photodiode is mentioned as the example. Here, the plane of incidence of a photo detector 21 is prepared in inclined plane 11a of optical waveguide 11, and the location which counters so that it may intersect perpendicularly with the principal plane of the multilayer-interconnection substrate 2.
[0031] A light emitting device 31 changes into a lightwave signal the electrical signal inputted into a light emitting device 31 through the electric wiring 3 of the multilayer-interconnection substrate 2, and carries out outgoing radiation of the lightwave signal from an outgoing radiation side to inclined plane 11b of optical waveguide 11, and light emitting diode (LED:Light Emitting Diode) is mentioned as the example. In addition, the outgoing radiation side of a light emitting device 31 is established in inclined plane 11b of optical waveguide 11, and the location which counters so that it may intersect perpendicularly with the principal plane of the multilayer-interconnection substrate 2.
[0032] Electronic circuitries, such as a digital disposal circuit and a memory circuit, are accumulated by the IC chips 25 and 35, and a power source is supplied to them through the electric wiring 3 of the multilayer-interconnection substrate 2. Moreover, these IC chips 25 and 35 are electrically connected with the photo detector 21 and the light emitting device 31 by electric wiring 3, and it has the function which delivers and receives an electrical signal between a photo detector 21 and a light emitting device 31.
[0033] For example, the electrode pad (not shown) is prepared in a photo detector 21, a light emitting device 31, and the IC chips 25 and 35, respectively. These electrode pads are in contact with the spherical bump (projection) BP who consists of solder (Pb-Sn solder) which uses lead

(Pb) and tin (Sn) as a principal component. That is, a photo detector 21, a light emitting device 31, and the IC chips 25 and 35 are being electrically connected to the electric wiring 3 on the multilayer-interconnection substrate 2 by Bump BP while they are arranged on both sides of optical waveguide 11 in between. This bump BP copes with one example of the "connection electrode" of this invention. In addition, that by which coating of the solder was carried out to the spherule (field core) which consists of conductivity of the ball bump who consists of gold (Au), or copper (Cu) as a bump BP can also be used.
[0034] Next, an operation of this photoconductive wave equipment 1 is explained.
[0035] With this photoconductive wave equipment 1, it will be in the condition that a photo detector 21, a light emitting device 31, and the IC chips 25 and 35 can operate, with the power supplied, for example from the electric wiring 3 of the multilayer-interconnection substrate 2. In this condition, if an electrical signal is outputted to a light emitting device 31 from the IC chip 35, a light emitting device 31 will change an electrical signal into a lightwave signal, and will carry out outgoing radiation of the lightwave signal from an outgoing radiation side. Incidence is carried out to inclined plane 11b, it reflects by inclined plane 11b, and the lightwave signal by which outgoing radiation was carried out is introduced in optical waveguide 11. After it, the inside of optical waveguide 11 is spread, it reflects by inclined plane 11a, and incidence of this lightwave signal is carried out to the plane of incidence of a photo detector 21. The lightwave signal which carried out incidence to the photo detector 21 is changed into an electrical signal, and is inputted into the IC chip 25. Thus, high-speed transmission of the lightwave signal is carried out between the IC chip 35 and the IC chip 25. Moreover, signals which may be transmitted comparatively at a low speed, such as a low-speed control signal, are transmitted by the electric wiring 3 of the multilayer-interconnection substrate 2 with an electrical signal. Here, the transmission speed of a lightwave signal supports to one example of the "1st rate" of this invention, and the transmission speed of an electrical signal supports one example of the "2nd rate" of this invention, respectively.
[0036] thus, with the photoconductive wave equipment concerning the gestalt of this operation The signal which controls the supply and the IC chip 35, and the IC chip 25 of power to the IC chips 25 and 35, a photo detector 21, and a light emitting device 31 and which may be transmitted comparatively at a low speed The signal which can perform by the electric wiring 3 of the multilayer-interconnection substrate 2, and should be transmitted to a high speed between the IC chip 35 and the IC chip 25 can be transmitted with a lightwave signal by the light emitting device 31, optical waveguide 11, and the photo detector 21. Therefore, the problem of delay of the signal by CR time constant of electric wiring 3 is solvable. moreover, electromagnetism -- the problem of malfunction resulting from the problem of a **** noise or wave-like turbulence is also solvable.
[0037] Moreover, with the photoconductive wave equipment concerning the gestalt of this operation, on the multilayer-interconnection substrate 2, the IC chips 25 and 35, a photo detector 21, and a light emitting device 31 make optical waveguide 11 and Bump BP intervene, and are mounted, and optical waveguide 11 has also played the role of the spacer which secures the tooth space for stationing Bump BP while supporting the IC chips 25 and 35, a photo detector 21, and a light emitting device 31. For this reason, the IC chips 25 and 35, a photo detector 21, and a light emitting device 31 may be fixed by stability on the multilayer-interconnection substrate 2. Moreover, the distance of the IC chips 25 and 35, a photo detector 21 and a light emitting device 31, and electric wiring 3 is maintainable to a predetermined value with optical waveguide 11.
[0038] Next, with reference to drawing 2 thru/or drawing 12 , the manufacture approach of the photoconductive wave equipment concerning the gestalt of this operation is explained. In addition, drawing 2 thru/or drawing 4 are perspective views which express one production process, respectively. In drawing 5 , (A) is a perspective view showing one production process, and (B) expresses the cross-section structure which met the XB-XB line of (A). Drawing 6 , drawing 7 , and drawing 12 are sectional views which express one production process, respectively. In drawing 8 , drawing 9 , and drawing 11 , (A) is a perspective view which fractures and expresses a part of one production process, respectively, and (B) expresses the cross-

section structure which met the VIIIB-VIIIB line (drawing 8), IXB-IXB line (drawing 9), and XIB-XIB line (drawing 11) of (A), respectively.
[0039] As shown in drawing 2 , first, for example, quartz glass, lead glass, soda glass. Or the transparence substrate 51 excellent in the surface smoothness which consists of an ingredient (light transmission nature ingredient) which comparatively often penetrates the light applied to a visible region from ultraviolet areas, such as a mica (mica), is prepared. this transparence substrate 51 top -- for example, plasma CVD (Chemical Vapor Deposition) -- the substrate detached core 52 which consists of diacid-ized silicon (SiO2) with a thickness of 500nm is formed by approaches, such as law, a heat CVD method, or an optical CVD method. This substrate detached core 52 is for separating the transparence substrate 51 from optical waveguide 11. The detail is mentioned later. In addition, diacid-ized silicon is the ingredient of transparence from an ultraviolet area mostly to the light of a visible region. Next, on the substrate detached core 52, with a spin coat method, after applying an epoxy resin so that it may become the thickness of about 20 micrometers, heat-treatment is performed, and resin is solidified, for example, the up cladding layer 53 whose refractive index is 1.52 is formed.
[0040] Next, as shown in drawing 3 , on the up cladding layer 53, using an ingredient with a refractive index higher than the component of the up cladding layer 53 (for example, epoxy resin), by the formation approach of the up cladding layer 53, and the same approach, a refractive index is 1.54 and core layer 54' which is about 30 micrometers in thickness is formed.
[0041] Next, as shown in drawing 4 , the photoresist film (not shown) of a predetermined pattern is formed and RIE is performed by using this photoresist film as a mask. Thereby, core layer 54' becomes two or more estranged core layers 54 with a beltlike flat-surface configuration.
[0042] Next, as shown in drawing 5 , the lower cladding layer 55 whose thickness is about 20 micrometers is formed by the formation approach of the up cladding layer 53, and the same approach all over the transparence substrate 51 using the same ingredient as the up cladding layer 53.
[0043] In addition, after applying a photo-setting resin on each of those substrate layers, you may make it form the up cladding layer 53, a core layer 54, and the lower cladding layer 55 by performing an optical exposure to this photo-setting resin, and stiffening resin.
[0044] Next, as shown in drawing 6 , the photoresist film 56 of about 10 micrometers of thickness numbers is formed on the lower cladding layer 55. Next, after performing predetermined exposure processing and a development to the photoresist film 56 and processing the photoresist film 56 into a predetermined pattern for it, this photoresist film 56 by which pattern NINGU was carried out is heat-treated at the temperature for example, more than glass transition temperature. Thereby, the edge part of the photoresist film 56 flows and an inclined plane (the E section of drawing 6) is formed.
[0045] Next, as shown in drawing 7 , anisotropic etching of optical waveguide 11 is performed by using the photoresist film 56 as a mask using an RIE system or ECR (Electro Cyclotron Resonance; electron cyclotron resonance) equipment. Thereby, the configuration corresponding to the inclined plane of the photoresist film 56, i.e., the front face of the transparence substrate 51 and the inclined planes [as / whose exterior angles to make are 135 degrees of abbreviation] 11a and 11b, is formed in the both ends of optical waveguide 11. The photoresist film 56 is removed after it.
[0046] Next, as shown in drawing 8 , the multilayer-interconnection substrate 2 is prepared and the glue line 6 with a thickness of about 10 micrometers it is thin from photo-setting resins, such as a glass epoxy resin, is formed in the field of the request on this multilayer-interconnection substrate 2 by approaches, such as a spin coat method, a dip coating method, a spray method, or print processes.
[0047] Next, optical waveguide 11 is stuck to the multilayer-interconnection substrate 2 with which the glue line 6 is formed, reversing the top and bottom of the transparence substrate 51 in which optical waveguide 11 was formed, and performing alignment, as shown in drawing 9 . Then, where the optical waveguide 11 and the multilayer-interconnection substrate 2 by the side of the transparence substrate 51 are stuck, Light L is irradiated toward the multilayer-interconnection substrate 2 side from the transparence substrate 51 side. The photo-setting

resin which constitutes a glue line 6 hardens by this, and the multilayer-interconnection substrate 2 fixes in the location of a request of optical waveguide 11. If the short-time light L is irradiated with the big quantity of light at this time, a strain will arise in optical waveguide 11 and optical transmission loss will become large. Then, the exposure of Light L is performed over many hours with the comparatively small quantity of light. For example, when using an extra-high pressure mercury lamp (wavelength; g line (436nm) core), it is 10 mW/cm2. It carries out for 5 minutes with an output.
[0048] Drawing 10 is a graph showing the light transmittance of the epoxy resin (1mm in thickness) used in the gestalt of this operation as a core layer 54, the up cladding layer 53, and a lower cladding layer 55. An axis of ordinate shows light transmittance (unit;%), and the axis of abscissa shows the wavelength (unit: nm) of light. As drawing 10 also shows, this epoxy resin is light transmission nature resin which makes the light of the near-ultraviolet field of long wave length, and a visible region penetrate about 90% from about 350nm. Moreover, as described above, it has sufficient transparency, substrate applying [the transparence substrate 51 and / 52] them to a visible region from an ultraviolet area. The light L which follows, for example, is emitted from an extra-high pressure mercury lamp hardens completely the glue line 6 which penetrates the transparence substrate 51, the substrate detached core 52, and optical waveguide 11, and fully reaches to a glue line 6, for example, consists of a glass epoxy resin.
[0049] Next, the transparence substrate 51 and the multilayer-interconnection substrate 2 are dipped in a thin hydrogen fluoride (HF) solution or a buffer hydrogen fluoride (BHF;Buffered HF) solution in the condition that the multilayer-interconnection substrate 2 has fixed to optical waveguide 11. Thereby, as shown in drawing 11 , dissolution removal of the substrate detached core 52 formed between the transparence substrate 51 and optical waveguide 11 is carried out, it will be in the condition (lift off) that the transparence substrate 51 on the substrate detached core 52 was separated from optical waveguide 11, and optical waveguide 11 will be imprinted by the multilayer-interconnection substrate 2. After it, prewashing of the multilayer-interconnection substrate 2 with which optical waveguide 11 was imprinted is carried out bywater, it is washed, and is dried.
[0050] Next, as shown in drawing 12 , Bump BP is formed in the electrode pad which a photo detector 21, a light emitting device 31, and the IC chips 25 and 35 do not illustrate, respectively. The spherical section which specifically consists of gold formed at the tip of a golden thin line is stuck to a photo detector 21, a light emitting device 31, and the electrode pad of the IC chips 25 and 35 by pressure, respectively, as a thin line is pulled apart from the spherical section, between the spherical section and thin lines is cut, and Bump BP is formed. A photo detector 21, a light emitting device 31, and the IC chips 25 and 35 are mounted in the multilayer-interconnection substrate 2 by the flip-chip-bonding method after it, and the reflow of extent which does not give a damage to optical waveguide 11 is performed. Here, the flip-chip-bonding method carries out alignment of the electrode (wiring) which counters Bump BP and the bump BP prepared in the multilayer-interconnection substrate 2, sticks it, and means the approach of applying heat and a pressure and joining these. In addition, after supplying soldering paste to the location of the request on the multilayer-interconnection substrate 2 by print processes etc., without using the flip-chip-bonding method, a photo detector 21 etc. may be mounted and a reflow may be performed. Moreover, it is also possible to mount other components other than a photo detector 21, a light emitting device 31, and the IC chips 25 and 35, such as for example, a chip mold resistor, a capacitor, or an inductor.
[0051] Although illustration is not carried out to the last, the resin for the closures (for example, epoxy resin) is introduced using capillarity between the mounted photo detectors 21, the light emitting devices 31, and the IC chips 25 and 35 and the multilayer-interconnection substrates 2, and a photo detector 21, a light emitting device 31, and the IC chips 25 and 35 are closed. Thereby, a photo detector 21, a light emitting device 31, and the connection dependability of the IC chips 25 and 35 and electric wiring 3 improve.
[0052] Thus, even if it is the case where the multilayer-interconnection substrate 2 with surface large irregularity is used as a support base since it was made to imprint to the multilayer-interconnection substrate 2 after forming optical waveguide 11 beforehand on the transparence

substrate 51 excellent in surface smoothness by the manufacture approach of the photoconductive wave equipment concerning the gestalt of this operation, it is possible to produce the photoconductive wave equipment 1 which has the optical waveguide 11 with little optical transmission loss.
[0053] Moreover, since according to the gestalt of this operation the ceramic multilayer-interconnection substrate and printed-circuit board of low cost are comparatively used as a multilayer-interconnection substrate 2 and it was made to mount components, such as the IC chips 25 and 35, a photo detector 21, and a light emitting device 31, on this multilayer-interconnection substrate 2, components can be mounted easily. Furthermore, an electric wiring layer can be formed by the thin film technology on a silicon substrate, and the photoconductive wave equipment 1 which can perform the signal transmission by light, the signal transmission by the electrical and electric equipment, and an electric power supply to coincidence compared with the conventional method of mounting components on it can be manufactured more cheaply.
[0054] Moreover, since the optical waveguide 11 which divided into the thin film process which forms optical waveguide 11, and the thick-film process which forms the multilayer-interconnection substrate 2, and was formed of the thin film process was imprinted to the multilayer-interconnection substrate 2 according to the gestalt of this operation Even if it does not use the spin coat method with which film formation is made difficult on substrates other than a disc-like substrate, optical waveguide 11 can be formed easily on the substrate of other configurations, such as a polygon. Consequently, the degree of freedom of selections, such as a configuration of the substrate (here multilayer-interconnection substrate 2) as a support base of optical waveguide 11 and an ingredient, can plan breadth and manufacture cost reduction.
[0055] Moreover, while using the process which imprints optical waveguide 11, when it formed optical waveguide 11 in the transparence substrate 51 beforehand independently [the multilayer-interconnection substrate 2] like the gestalt of this operation, and the cross-section configuration (especially width of face) of optical waveguide 11 is formed greatly, the alignment of the IC chips 25 and 35 to optical waveguide 11, a light emitting device 21, and a photo detector 31 becomes easy, and it becomes possible to reduce a manufacturing cost also at this point.
[0056] In addition, with the gestalt of this operation, it was made to mount the IC chips 25 and 35, a light emitting device 21, and a photo detector 31 so that optical waveguide 11 might be touched by using optical waveguide 11 as a spacer, but as mentioned above, in case a reflow is performed at the time of mounting, it is necessary to pay attention so that a damage may not be given to optical waveguide 11. Therefore, by using Bump BP as a spacer, you may mount so that optical waveguide 11, the IC chips 25 and 35, a light emitting device 21, and a photo detector 31 may estrange. In that case, while the distance of the IC chips 25 and 35, a light emitting device 21 and a photo detector 31, and electric wiring 3 is maintained by Bump BP at a predetermined value, reliable electrical installation becomes possible.
[0057] (Gestalt of the 2nd operation) The gestalt of this operation is related with the manufacture approach of photoconductive wave equipment. The photoconductive wave equipment used as the object is the same as that of the gestalt of implementation of the above 1st except for the point that between each optical waveguide is separated. Hereafter, with reference to drawing 1 thru/or drawing 5 and drawing 13 thru/or drawing 20 , the manufacture approach of the photoconductive wave equipment of the gestalt this operation is explained. Drawing 13 thru/or drawing 20 are perspective views which fracture and express a part of each production process, respectively. In addition, the same sign is given to the same component as the gestalt of the 1st operation, and the detailed explanation is omitted here.
[0058] By the manufacture approach concerning the gestalt of this operation, the substrate detached core 52 and optical waveguide 11 are first formed on the transparence substrate 51 like the process shown in drawing 2 of the gestalt of the 1st operation - drawing 5 .
[0059] next, it was shown in drawing 13 — as — an optical waveguide 11 top — for example, plasma CVD (Chemical Vapor Deposition) — the stratum disjunctum 91 which consists of diacid-ized silicon (SiO_2) with a thickness of 500nm is formed by approaches, such as law, a heat CVD method, or an optical CVD method. This stratum disjunctum 91 is for removing

alternatively the light-shielding film 92 (referring to drawing 15) mentioned later. Then, the front face of the transparence substrate 51 and the inclined planes [as / whose exterior angles to make are 135 degrees of abbreviation] 11a and 11b (here, not shown) are formed in the both ends of optical waveguide 11 using the same lithography technique as the gestalt of the 1st operation.
[0060] Next, as shown in drawing 14 , stratum disjunctum 91, optical waveguide 11, and the substrate detached core 52 are alternatively removed by forming the photoresist film of the predetermined pattern which is not illustrated and performing etching processing of laser beam machining or plasma etching and ion beam etching for example, using the oxygen (O) plasma, etching (powder beam etching) using powder, etc. by using this photoresist film as a mask. Here, since it is necessary to remove certainly until it reaches the inferior surface of tongue (namely, interface of the up cladding layer 53 and the substrate detached core 52) of optical waveguide 11, it is made to perform laser radiation or etching until the substrate detached core 52 is exposed. Thereby, the stratum disjunctum 91 formed optical waveguide 11 and on it is divided to two or more optical waveguide 11' and stratum disjunctum 91' which were estranged mutually. In addition, when the part to remove is the simple pattern constituted by the straight line, you may make it dicing etc. remove.
[0061] Next, as shown in drawing 15 , the light-shielding film 92 which consists of chromium (Cr) with a thickness of 100nm is formed in the transparence substrate 51, optical waveguide 11, and the whole exposure of stratum disjunctum 91 by vacuum deposition or the spatter. In addition, in case a light-shielding film 92 exposes and stiffens the glue line 6 mentioned later, it is for shading alternatively. Incidentally, as long as it is the ingredient which can intercept light as a component of a light-shielding film 92, ingredients other than chromium may be used. Specifically, aluminum, a tantalum (Ta), etc. may be used.
[0062] Next, as shown in drawing 16 , the light-shielding film 92 to which it is in contact with stratum disjunctum 91' (namely, on optical waveguide 11) is alternatively removed by carrying out dissolution removal of stratum disjunctum 91' which consists of diacid-ized silicon using a rare fluoric acid solution (the lift-off method). This will be in the condition that only the top face of optical waveguide 11 was exposed.
[0063] Next, as shown in drawing 17 , the multilayer-interconnection substrate 2 is prepared and the glue line 6 with a thickness of about 10 micrometers it is thin from photo-setting resins, such as a glass epoxy resin, is formed in the field of the request on this multilayer-interconnection substrate 2 by approaches, such as a spin coat method, a dip coating method, a spray method, or print processes.
[0064] Next, after carrying out top-and-bottom reversal of the transparence substrate 51 with which optical waveguide 11' was formed like the process shown in drawing 9 of the gestalt of the 1st operation and sticking the multilayer-interconnection substrate 2 to optical waveguide 11' by pressure as shown in drawing 18 for example, Light L is irradiated towards the direction of the multilayer-interconnection substrate 2 from the transparence substrate 51 side. Here, it is formed only in the field in which a light-shielding film 92 is not formed in the interface of optical waveguide 11' and a glue line 6, and optical waveguide 11' of the side face of optical waveguide 11' and the opposed faces with the multilayer-interconnection substrate 2 of the transparence substrate 51 is not formed. Therefore, the light L irradiated from the transparence substrate 51 side reaches to a glue line 6 only in the field A in which optical waveguide 11' is formed, is intercepted by the light-shielding film 92 in the other fields B, and does not reach to a glue line 6. Consequently, the field A of the lower part of optical waveguide 11' hardens among glue lines 6, and the other fields B serve as as [un-hardening]. And the multilayer-interconnection substrate 2 fixes to optical waveguide 11' by this hardened glue line 6.
[0065] Next, as shown in drawing 19 , dissolution removal of the resin of the field B with un-hardening is alternatively carried out by the acetone or ethanol, without Light L being irradiated by the light-shielding film 92 of the glue lines 6.
[0066] Next, after dissolving the light-shielding film 92 which consists of chromium using an acidic solution (for example, solution of hydrochloric acid) as shown in drawing 20 for example, optical waveguide 11' is imprinted to the multilayer-interconnection substrate 2 by carrying out

dissolution removal of the substrate detached core 52 by the approach of the process shown in drawing 11 of the gestalt of the 1st operation, and the same approach. The following processes are the same as the gestalt of the 1st operation.
[0067] Thus, while forming beforehand two or more optical waveguide 11' separated mutually on the transparence substrate 51 with the gestalt of this operation Since the glue line 6 in the condition of not hardening and optical waveguide 11' which were formed all over the multilayer-interconnection substrate 2 using the light-shielding film 92 are stuck and it was made to stiffen alternatively only the glue line 6 of the lower part of an optical waveguide 11' formation field Two or more optical waveguide 11' on the transparence substrate 51 can be imprinted good to the multilayer-interconnection substrate 2. That is, on the multilayer-interconnection substrate 2, it estranges mutually, and is formed, and two or more optical waveguide 11' with little optical transmission loss can be arranged.
[0068] Moreover, although the case where a flat-surface configuration formed two or more band-like optical waveguide 11' was explained here The flat-surface configuration of the arbitration formed on the transparence substrate 51 when using the manufacture approach of the gestalt this operation Optical waveguide can be imprinted only in a required part, without imprinting in the field which he can imprint [field] (optical waveguide [for example,], such as shape of shape [of L character], shape [of U character], and radii) 11' to the multilayer-interconnection substrate 2, for example, does not want to imprint optical waveguide like the electrode formation field of the multilayer-interconnection substrate 2.
[0069] (Gestalt of the 3rd operation) The gestalt of operation of the 3rd of this invention is the same as that of what showed the structure of the photoconductive wave equipment as the object itself to drawing 1 about the manufacture approach of optical waveguide. Except for the point that the formation approaches of the inclined planes 11a and 11b of optical waveguide 11 differ, as for the manufacture approach of the photoconductive wave equipment concerning the gestalt of this operation, others are the same as that of the gestalt of the 1st operation. Hereafter, it explains with reference to drawing 21 thru/or drawing 23 . In addition, in these drawings, the same sign is given to the same component as the gestalt of the 1st operation, and the detailed explanation is omitted here.
[0070] By the formation approach of the inclined plane of the gestalt this operation, first, as shown in drawing 21 , the optical waveguide 11 which consists of the up cladding layer 53, a core layer 54, and a lower cladding layer 55 through the substrate detached core 52 is formed on the transparence substrate 51. Next, the metal membrane 60 which consists of aluminum is formed with vacuum deposition on the lower cladding layer 55. Next, after forming the photoresist film 56 on a metal membrane 60, while performing predetermined exposure and a development to the photoresist film 56 and forming a desired photoresist pattern, an inclined plane E is formed in the edge part of the photoresist film 56 by heat-treating the photoresist film 56 at the temperature for example, more than glass transition temperature.
[0071] Next, as shown in drawing 22 , by using the photoresist film 56 as a mask, a metal membrane 60 is etched and let the both ends of a metal membrane 60 be the inclined planes F of the configuration corresponding to the inclined plane E of the photoresist film 56.
[0072] Next, it is CO_2 from a desired include angle, using a metal membrane 60 as a mask, as shown in drawing 22 . The laser beams LB, such as gas laser, are irradiated and optical waveguide 11 is cut. It is made for the cutting plane used as the edge of optical waveguide 11 to turn into the inclined planes 11a and 11b which inclined at 45 degrees of abbreviation to the longitudinal direction (the optical propagation direction) of optical waveguide 11 at this time. The process after it is the same as the gestalt of the 1st operation.
[0073] Thus, since it carries out by irradiating a laser beam LB to formation of the inclined planes 11a and 11b of the edge of optical waveguide 11 from a predetermined include angle, and cutting optical waveguide 11 according to the gestalt of this operation, it can form often [precision] and easily rather than the case where inclined planes 11a and 11b are formed only according to a thin film formation process.
[0074] (Gestalt of the 4th operation) The gestalt of operation of the 4th of this invention is the same as that of what showed the structure of the photoconductive wave equipment as the

object itself to drawing 1 about the manufacture approach of optical waveguide. Except for the point that the formation approaches of the inclined planes 11a and 11b of optical waveguide 11 differ, as for the manufacture approach of the photoconductive wave equipment concerning the gestalt of this operation, others are the same as that of the gestalt of the 1st operation. Hereafter, it explains with reference to drawing 24 thru/or drawing 27 . In addition, in these drawings, the same sign is given to the same component as the gestalt of the 1st operation, and the detailed explanation is omitted here.
[0075] In the gestalt of this operation, first, as shown in drawing 24 , in the same process as the gestalt of the 1st operation, the substrate detached core 52 is formed on the transparence substrate 51, and the optical waveguide 11 which consists of the up cladding layer 53, a core layer 54, and a lower cladding layer 55 on this is formed.
[0076] Next, as shown in drawing 25 , the heat tool T which has two letter slant faces Ta of beveling which incline at 45 degrees of abbreviation to an apical surface Tb is prepared, and it heats to the temperature more than the glass transition temperature of the resin material which constitutes the up cladding layer 53, the core layer 54, and the lower cladding layer 55 which constitute optical waveguide 11 for this heat tool T. Then, the tip of the heated heat tool T is forced on the multilayer-interconnection substrate 2, and optical waveguide 11 is fused. As long as it is required, you may make it move the heat tool T in the direction in alignment with the principal plane of the multilayer-interconnection substrate 2.
[0077] Next, if the heat tool T is removed from the multilayer-interconnection substrate 2 as shown in drawing 26 , Crevice H will be formed in the field to which melting of the optical waveguide 11 was carried out, and the inside of Crevice H will turn into the inclined planes 11a and 11b which inclined at 45 degrees of abbreviation to the longitudinal direction of optical waveguide 11. In addition, around Crevice H, Society for Cutting Up Men (processing waste) K is generated according to heat deformation. For this reason, the forming face of Society for Cutting Up Men K of a substrate 51 is forced on the polished surface of the GURAINDO substrate 71, and is ground lightly. As shown in drawing 27 , while Society for Cutting Up Men K around Crevice H is removed by this polish, flattening of the top face of optical waveguide 11 is carried out. The inclined planes 11a and 11b of optical waveguide 11 are completed by finally performing washing / desiccation processing. The process after it is the same as the gestalt of the 1st operation.
[0078] Thus, according to the gestalt of this operation, since he is trying to form the inclined planes 11a and 11b of optical waveguide 11 by the slant face Ta of the heat tool T, these inclined planes 11a and 11b can be formed in whenever [same tilt-angle / as the slant face Ta of the heat tool T], and the precision of inclined planes 11a and 11b can be raised.
[0079] (Gestalt of the 5th operation) The gestalt of operation of the 5th of this invention is the same as that of what showed the structure of the photoconductive wave equipment as the object itself to drawing 1 about the manufacture approach of optical waveguide. Except for the point that the formation approaches of the inclined planes 11a and 11b of optical waveguide 11 differ, as for the manufacture approach of the photoconductive wave equipment concerning the gestalt of this operation, others are the same as that of the gestalt of the 1st operation. Hereafter, it explains with reference to drawing 28 thru/or drawing 30 . In addition, in these drawings, the same sign is given to the same component as the gestalt of the 1st operation, and the detailed explanation is omitted here.
[0080] In the gestalt of this operation, first, as shown in drawing 28 , in the same process as the gestalt of the 1st operation, the substrate detached core 52 is formed on the transparence substrate 51, and the optical waveguide 11 which consists of the up cladding layer 53, a core layer 54, and a lower cladding layer 55 on this is formed.
[0081] Next, as shown in drawing 29 , cutting means, such as a dicing saw, cut the transparence substrate 51 with which optical waveguide 11 was formed at the include angle of 45 degrees to the longitudinal direction (the optical propagation direction) of optical waveguide 11 (the F section of drawing 29).
[0082] Next, as shown in drawing 30 , the cut transparence substrate 51 is made to incline at the include angle of 45 degrees to the GURAINDO substrate 81, and the cutting plane of the

transparence substrate 51 is contacted to the polished surface of the GURAINDO substrate 81, and is ground. Inclined plane 11a which inclines at 45 degrees to the longitudinal direction of optical waveguide 11 by this in the end section of optical waveguide 11 can be formed. The following processes are the same as the gestalt of the 1st operation almost.
[0083] Thus, according to the gestalt of this operation, since he is trying to grind mechanically inclined plane 11a of optical waveguide 11, the precision of inclined plane 11a can be raised. In addition, since end-face processing of optical waveguide 11 by which two or more arrays were carried out along with the principal plane of the transparence substrate 51 can be put in block and the formation approach of this inclined plane 11a can perform it, it is convenient.
[0084] (Gestalt of the 6th operation) The gestalt of operation of the 6th of this invention is related with the photoconductive wave equipment constituted as an optical transceiver module which transmits and receives data through a 1 heart optical fiber. Drawing 31 expresses the cross-section structure of the photoconductive wave equipment concerning the gestalt of this operation. In addition, the same sign is given to the same component as the gestalt of the 1st operation, and the explanation is omitted here.
[0085] This photoconductive wave equipment The multilayer-interconnection substrate 2 (for example, glass epoxy multilayer-interconnection substrate), The laser diode 101 and the IC chip 102 of the edge surface-emitting type as a light emitting device the optical waveguide 11 formed on the multilayer-interconnection substrate 2, and for the transmission mounted through Bump BP on the multilayer-interconnection substrate 2, It has the photo detector 103 embedded at the multilayer-interconnection substrate 2, the photo detector 103 on the multilayer-interconnection substrate 2, and the 1 heart optical fiber 201 arranged in the location which counters. Moreover, it is possible to carry the circuit and components of the others represented in the drive circuit of a laser diode 101 and receiving circuits, such as transimpedance amplifier, on the multilayer-interconnection substrate 2 (not shown).
[0086] Optical waveguide 11 was imprinted on the multilayer-interconnection substrate 2 by the approach of the gestalt the 1st operation, and has fixed to the multilayer-interconnection substrate 2 by the glue line 6 which served as the passivation film which consists of resin. The front face of the multilayer-interconnection substrate 2 and the exterior angle to make are 45 degrees of abbreviation, and inclined plane 11a which functions as a reflector is formed in the end of optical waveguide 11. Optical waveguide 11 is positioned so that the location of inclined plane 11a may come to the center section of the photo detector 103. The photo detector 103 has sensibility to the wavelength of the light which receives light.
[0087] The 1 heart optical fiber 201 consists of a fiber core layer 202 formed in the interior, and a fiber cladding layer 203 formed in the periphery of the fiber core layer 202, and it is prepared so that the end section may estrange only a predetermined distance from a photo detector 103. The diameter of the fiber core layer 202 is large enough compared with the magnitude of inclined plane 11a.
[0088] It is inputted into optical waveguide 11, optical waveguide 11 is spread, it reflects at inclined plane 11a, and the lightwave signal outputted from the laser diode 101 with this photoconductive wave equipment is the outgoing radiation light Lout. It carries out and is efficiently introduced into the 1 heart optical fiber 201. Moreover, the quantity of light of the incident light Lin outputted from the 1 heart optical fiber 201 kicked by inclined plane 11a although the large field of the multilayer-interconnection substrate 2 containing inclined plane 11a of optical waveguide 11 irradiates is slight, and since most incident light Lin is absorbed by light sensing portion 103a of a photo detector 103, it can perform efficient reception.
[0089] Thus, according to the gestalt of this operation, it becomes large, and it is low cost and the degree of freedom of arrangement between the 1 heart optical fiber 201, and a photo detector 103 and a laser diode 101 can consider as a powerful optical transceiver module.
[0090] As mentioned above, although the gestalt of some operations was mentioned and this invention was explained, this invention is not limited to the gestalt of each above-mentioned implementation, and is variously deformable. For example, although considered as the configuration on which the lower cladding layer 55 of optical waveguide 11 was pasted up on the glue line 6 with the gestalt of the above-mentioned implementation, if the ingredient which

achieves the same function as the lower cladding layer 55 constitutes a glue line 6, the lower cladding layer 55 can consider as the configuration which serves as the glue line 6. Moreover, it is also possible to consider as the configuration which does not form the up cladding layer 53 about the up cladding layer 53, either, as uses air as a cladding layer in case optical waveguide 11 is imprinted to the multilayer-interconnection substrate 2. These results, the formation process of optical waveguide 11 can be simplified and a manufacturing cost can be reduced.
[0091] Moreover, thermosetting resin can also be used although the gestalt of implementation of the above 1st explained the case where a photo-setting resin was used as a formation ingredient of a glue line 6. In this case, after forming optical waveguide 11 in the transparence substrate 51, the glue line 6 which consists of thermosetting resin, such as an epoxy resin or acrylic resin, by print processes is formed in the field of the request on the multilayer-interconnection substrate 2, and it heats in the condition of having made the optical waveguide 11 on the transparence substrate 51 sticking the multilayer-interconnection substrate 2. The thermosetting resin which constitutes a glue line 6 hardens by this, and the multilayer-interconnection substrate 2 fixes to optical waveguide 11. In this case, the substrate for optical waveguide formation (the 1st substrate in this invention) may not be the thing of light transmission nature. However, in order to make alignment in the case of an imprint easy, it is desirable to use the substrate of transparence.
[0092] Moreover, although this substrate detached core 52 is dipped in a thin hydrogen fluoride solution or a buffer hydrogen fluoride solution and it was made to carry out dissolution removal with the gestalt of the above-mentioned implementation while using diacid-ized silicon as a formation ingredient of the substrate detached core 52, it is possible to spray organic solvents, such as an acetone or isopropyl alcohol, in the shape of a shower, to dissolve the substrate detached core 52, and to also make the substrate detached core 52 and optical waveguide 11 separate by these interfaces. Furthermore, the substrate detached core 52 is formed with the metallic material in which wet etching, such as aluminum (aluminum) and copper, is possible, and it may be made to carry out dissolution removal of this substrate detached core 52 using solutions, such as a thin hydrochloric acid (HCl), a sodium hydroxide (NaOH), or a potassium hydroxide (KOH).
[0093] Moreover, although light transmission nature ingredients, such as quartz glass, were used as a transparence substrate 51, you may make it use ingredients, such as photosensitive glass which has light transmission nature and can dissolve, with the gestalt of the above-mentioned implementation. In this case, since it dissolves by dipping in the rare hydrogen fluoride solution for example, below 5 volume %, photosensitive glass becomes unnecessary [the substrate detached core 52].
[0094] Moreover, although the light reflex section (inclined planes 11a and 11b) was prepared in the whole end face of optical waveguide 11, you may make it prepare only in the end face of a core layer 54 with the gestalt of the above-mentioned implementation.
[0095]
[Effect of the Invention] Since this optical waveguide is arranged on a substrate and it was made to fix according to photoconductive wave equipment given in any 1 term of claim 1 thru/or claim 24 as explained above while forming optical waveguide separately beforehand, it becomes possible to collateralize a fixed property, without being influenced by the class and configuration of a substrate which support optical waveguide unlike the case where direct optical waveguide is formed on a substrate. Therefore, the effectiveness that it can constitute using the substrate of arbitration is done so.
[0096] Since it constituted especially according to photoconductive wave equipment given in any 1 term of claim 8 thru/or claim 24 so that optical waveguide, a light emitting device, or a photo detector might reach on the other hand at least and it might have an integrated circuit on the substrate with which electric wiring was formed While carrying out high-speed transmission of the signal which should be transmitted to a high speed as a lightwave signal, the signal which may be transmitted comparatively at a low speed can also use a transmission gestalt properly according to an application or the purpose as it transmits as an electrical signal. Therefore, when transmitting with electric wiring, while the propagation delay of the signal which poses a problem

is canceled, malfunction which a possibility that it may be influenced of an electromagnetic noise decreases, consequently originates in wave-like turbulence can be prevented effectively. Therefore, if this photoconductive wave equipment is used, only with electric wiring, signal transfer of the high speed implementation was difficult the high speed will be attained, and it will also become possible to raise the engine performance of a system or a network by leaps and bounds.
[0097] Moreover, since the optical waveguide formed on the 1st substrate was imprinted to the 2nd substrate according to the manufacture approach of photoconductive wave equipment given in any 1 term of claim 25 thru/or claim 61, the effectiveness that the optical waveguide which was able to be formed only on the expensive substrate which was excellent in thermal resistance in the former can be formed on the cheaper substrate of the ingredient of arbitration and a configuration is done so. Furthermore, optical waveguide with little optical transmission loss is producible by using the substrate which was excellent in surface smoothness as the 1st substrate.
[0098] According to the manufacture approach of photoconductive wave equipment given in any 1 term of claim 34 thru/or claim 36, especially After forming two or more optical waveguides estranged mutually on the 1st substrate and pasting up the 2nd substrate on such optical waveguides through a glue line, Since only the field corresponding to the field in which optical waveguide is formed among glue lines is exposed alternatively and it was made to stiffen it, two or more optical waveguides mutually divided into the field of a request of the substrate of arbitration can be imprinted.
[0099] Moreover, since the electric wiring substrate beforehand formed of the thick-film process was used as the 2nd substrate according to the manufacture approach of photoconductive wave equipment given in any 1 term of claim 39 thru/or claim 61, after forming electric wiring on a substrate using a thin film technology, it can manufacture easily and more cheaply than the case where optical waveguide is formed on it.
[0100] Since what contains at least one sort of polyimide and an epoxy resin cheaper than a quartz, acrylic resin, polyolefin resin, or synthetic rubber as an ingredient which forms the 1st and 2nd cladding layers was used especially according to the manufacture approach of photoconductive wave equipment according to claim 48, reduction-ization of the ingredient cost of optical waveguide can be attained.
[0101] Moreover, according to the manufacture approach of photoconductive wave equipment according to claim 52, since it was made to carry out by [of optical waveguide] irradiating a laser beam to formation of the inclined plane of the end section from a predetermined include angle, and cutting optical waveguide at least, it can form often [precision] and easily rather than the case where it forms only according to a thin film formation process.
[0102] Moreover, since at least 1 end face of optical waveguide was processed on the inclined plane by heating the heating tool which has the inclined plane of a predetermined include angle in a point, and carrying out a closet to optical waveguide according to the manufacture approach of photoconductive wave equipment according to claim 53, the inclined plane of optical waveguide can be formed in whenever [same tilt-angle / as the inclined plane of a heating tool], and the precision can be raised.
[0103] Moreover, since the end face formed of cutting of the 1st substrate is ground and it was made to consider as the inclined plane of optical waveguide after cutting the 1st substrate with which optical waveguide was formed at an angle of predetermined according to the manufacture approach of photoconductive wave equipment according to claim 54, the precision of an inclined plane can be raised.
[0104] Moreover, since optical waveguide was used as a spacer which a light emitting device or a photo detector reaches on the other hand at least, and intervenes between an integrated circuit and the 2nd substrate according to photoconductive wave equipment according to claim 60, on the other hand, a light emitting device or a photo detector can reach at least, and an integrated circuit can be fixed to stability on the 2nd substrate.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a sectional view showing the configuration of the photoconductive wave equipment concerning the gestalt of operation of the 1st of this invention.
[Drawing 2] It is a perspective view for explaining one production process of the photoconductive wave equipment concerning the gestalt of operation of the 1st of this invention.

[Drawing 3] It is a perspective view for explaining the production process following drawing 2 .
[Drawing 4] It is a perspective view for explaining the production process following drawing 3 .
[Drawing 5] (A) is the perspective view fractured for explaining the production process following drawing 4 the part, and (B) is the sectional view which met the XB-XB line of (A).
[Drawing 6] It is a sectional view for explaining the production process following drawing 5 .
[Drawing 7] It is a sectional view for explaining the production process following drawing 6 .
[Drawing 8] (A) is the perspective view fractured for explaining the production process following drawing 7 the part, and (B) is the sectional view which met the VIIIB-VIIIB line of (A).
[Drawing 9] (A) is the perspective view fractured for explaining the production process following drawing 8 the part, and (B) is the sectional view which met the IXB-IXB line of (A).
[Drawing 10] It is property drawing showing the relation between the light transmittance of the epoxy resin used in the gestalt of operation of the 1st of this invention, and the wavelength of light.
[Drawing 11] (A) is the perspective view fractured for explaining the production process following drawing 9 the part, and (B) is the sectional view which met the XIB-XIB line of (A).
[Drawing 12] It is a sectional view for explaining the production process following drawing 11 .
[Drawing 13] It is the perspective view which carried out the cross section for explaining one production process of the photoconductive wave equipment concerning the gestalt of operation of the 2nd of this invention the part.
[Drawing 14] It is the perspective view fractured for explaining the production process following drawing 13 the part.
[Drawing 15] It is the perspective view fractured for explaining the production process following drawing 14 the part.
[Drawing 16] It is the perspective view fractured for explaining the production process following drawing 15 the part.
[Drawing 17] It is the perspective view fractured for explaining the production process following drawing 16 the part.
[Drawing 18] It is the perspective view fractured for explaining the production process following drawing 17 the part.
[Drawing 19] It is the perspective view fractured for explaining the production process following drawing 18 the part.
[Drawing 20] It is the perspective view fractured for explaining the production process following drawing 19 the part.
[Drawing 21] It is a sectional view for explaining one production process of the photoconductive wave equipment concerning the gestalt of operation of the 3rd of this invention.

[Drawing 22] It is a sectional view for explaining the production process following drawing 21 .
[Drawing 23] It is a sectional view for explaining the production process following drawing 22 .
[Drawing 24] It is a sectional view for explaining one production process of the photoconductive wave equipment concerning the gestalt of operation of the 4th of this invention.
[Drawing 25] It is a sectional view for explaining the production process following drawing 24 .
[Drawing 26] It is a sectional view for explaining the production process following drawing 25 .
[Drawing 27] It is a sectional view for explaining the production process following drawing 26 .
[Drawing 28] It is a sectional view for explaining one production process of the photoconductive wave equipment concerning the gestalt of operation of the 5th of this invention.
[Drawing 29] It is a sectional view for explaining the production process following drawing 28 .
[Drawing 30] It is a sectional view for explaining the production process following drawing 29 .
[Drawing 31] It is a sectional view showing the configuration of the photoconductive wave equipment concerning the gestalt of operation of the 6th of this invention.
[Drawing 32] It is a sectional view showing the example of 1 configuration of conventional photoconductive wave equipment.
[Description of Notations]
1 [-- An insulator, 6 / -- Glue line,] -- Photoconductive wave equipment, 2 -- A multilayer-interconnection substrate, 3 -- Electric wiring, 4 11 11' -- Optical waveguide, 11a, 11b -- An inclined plane, 21 -- Photo detector, 25 35 [-- A substrate detached core, 53 / -- An up cladding layer, 54 / -- A core layer, 55 / -- A lower cladding layer, 56 / -- The photoresist film, 91, 91' / -- Stratum disjunctum, 92 / -- A light-shielding film, BP / -- A bump, L / -- Light, LB / -- Laser beam] -- IC chip, 31 -- A light emitting device, 51 -- A transparence substrate, 52

[Translation done.]

OPTICAL WAVE GUIDE DEVICE AND ITS MANUFACTURE

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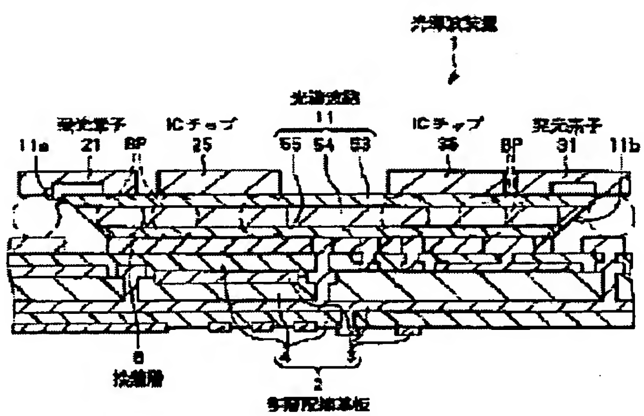
Abstract of **JP2000199827**

PROBLEM TO BE SOLVED: To provide an optical wave guide device having an optical waveguide warranting a high optical propagation characteristic regardless of a kind of a support pedestal and its manufacture. SOLUTION: This optical wave guide device is provided with a multilayer wiring substrate 2, an optical waveguide 11, a light receiving element 21, IC chips 25, 35 and a light emitting element 31 arranged on the multilayer wiring substrate 2. Since the optical waveguide 11 is formed on a flat transparent substrate, and is transferred onto the multilayer wiring substrate 2, it has an advantage such as a less optical propagative loss. At this time, a signal to be transmitted at high speed is high speed transmitted as an optical signal, and the signal allowed to be transmitted at a relatively low speed is transmitted as an electric signal. Thus, the propagative delay of the signal becoming a problem in the case of transmitting only by the electric signal is dissolved, and the danger receiving an effect of an electromagnetic noise is reduced.



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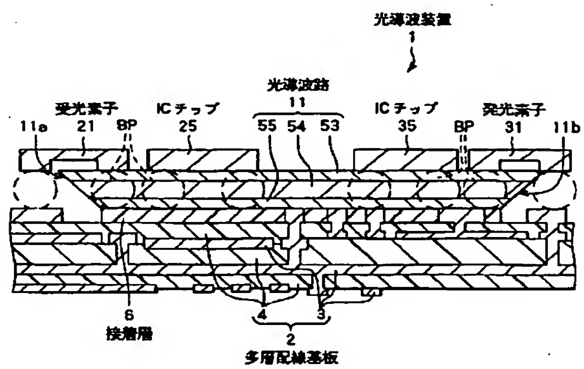
(54)【発明の名称】　光導波装置およびその製造方法

(57)【要約】
【課題】　支持基体の種類にかかわらず、高い光伝搬特性を担保し得る光導波路を有する光導波装置およびその製造方法を提供する。
【解決手段】　多層配線基板２と、多層配線基板２上に配設された光導波路１１、受光素子２１、ＩＣチップ２５，３５および発光素子３１とを備えている。光導波路１１は、平坦性に優れた透明基板上に形成されたのち、多層配線基板２に転写されたものであるので、光伝搬損失が少ないという利点を有する。ここでは、高速に伝送すべき信号は光信号として高速伝送され、比較的低速で伝送してもよい信号は電気信号として伝送される。よって、電気信号のみにより伝送する場合に問題となる信号の伝搬遅延が解消されると共に、電磁的ノイズの影響を受けるおそれが少なくなる。



【特許請求の範囲】

【請求項１】　基板と、
内部を光信号が伝搬しうるように予め別途形成されると共に、前記基板上に配置されて固着された光導波路とを備えたことを特徴とする光導波装置。

【請求項２】　前記基板に電気的配線が形成されていることを特徴とする請求項１記載の光導波装置。

【請求項３】　更に、前記基板上に、電気信号を光信号に変換するための発光素子または光信号を電気信号に変換するための受光素子の少なくとも一方を備えたことを特徴とする請求項１記載の光導波装置。

【請求項４】　更に、前記基板上に、前記発光素子または前記受光素子の少なくとも一方との間で電気信号の授受を行うための集積回路を備えたことを特徴とする請求項３記載の光導波装置。

【請求項５】　前記光導波路は、前記基板とは異なる他の基板上に形成されて、前記他の基板から前記基板上に転写されたものであることを特徴とする請求項１記載の光導波装置。

【請求項６】　前記光導波路は、少なくとも一端に、外部からの光信号を反射させて前記光導波路内に導入する機能、または前記光導波路内を伝搬してきた光信号を反射させて前記光導波路外に導出する機能の少なくとも一方を有する光反射部を有することを特徴とする請求項１記載の光導波装置。

【請求項７】　前記光導波路はコア層とクラッド層とを含んで構成されると共に、前記光反射部は前記コア層の少なくとも一端に設けられていることを特徴とする請求項６記載の光導波装置。

【請求項８】　更に、前記基板上に、
電気信号を光信号に変換するための発光素子または光信号を電気信号に変換するための受光素子の少なくとも一方と、
前記発光素子または前記受光素子の少なくとも一方との間で電気信号の授受を行うための集積回路とを備えると共に、前記光導波路は、少なくとも一端に光信号の入力または出力を行うための光反射部を有し、接着層を介して前記基板に接着されていることを特徴とする請求項２記載の光導波装置。

【請求項９】　前記基板の電気的配線は、前記発光素子または前記受光素子の少なくとも一方および前記集積回路に電源を供給するためのものであることを特徴とする請求項８記載の光導波装置。

【請求項１０】　前記基板の電気的配線は、前記発光素子または前記受光素子の少なくとも一方と前記集積回路とを電気的に結合するためのものであることを特徴とする請求項８記載の光導波装置。

【請求項１１】　前記基板は、複数の電気的配線層が絶縁体を介して積層された多層配線基板であることを特徴とする請求項８記載の光導波装置。

【請求項１２】　前記光導波路は、前記基板上に形成された第１のクラッド層と、この第１のクラッド層上に積層されたコア層と、このコア層上に積層された第２のクラッド層とを含んで構成されていることを特徴とする請求項８記載の光導波装置。

【請求項１３】　前記第１のクラッド層は、前記接着層を兼ねていることを特徴とする請求項１２記載の光導波装置。

【請求項１４】　前記接着層は、光硬化性樹脂よりなることを特徴とする請求項８記載の光導波装置。

【請求項１５】　前記接着層は、熱硬化性樹脂よりなることを特徴とする請求項８記載の光導波装置。

【請求項１６】　前記発光素子または受光素子の少なくとも一方および前記集積回路は、接続電極によって前記基板の電気的配線に接続されていることを特徴とする請求項８記載の光導波装置。

【請求項１７】　前記接続電極は、導電性材料よりなる球状体にはんだがコーティングされたものであることを特徴とする請求項１６記載の光導波装置。

【請求項１８】　前記接続電極は、鉛（Ｐｂ）および錫（Ｓｎ）を主成分とするはんだよりなることを特徴とする請求項１６記載の光導波装置。

【請求項１９】　前記光導波路は第１の速度で伝送信号の伝送を行うものであり、前記基板の電気的配線は前記第１の速度よりも小さい第２の速度で伝送信号の伝送を行うものであることを特徴とする請求項８記載の光導波装置。

【請求項２０】　前記発光素子、受光素子または集積回路の少なくとも１つは、前記光導波路を前記基板との間に介在するスペーサとして、前記基板上に配設されていることを特徴とする請求項８記載の光導波装置。

【請求項２１】　前記光反射部は、
前記光導波路の少なくとも一端面に形成された傾斜面により構成されると共に、
外部からの光信号を反射させて前記光導波路内に導入する機能、または前記光導波路内を伝搬してきた光信号を反射させて前記光導波路外に導出する機能の少なくとも一方を有することを特徴とする請求項８記載の光導波装置。

【請求項２２】　前記傾斜面は、前記光導波路内の光伝搬方向に対して略４５度に傾斜していることを特徴とする請求項２１記載の光導波装置。

【請求項２３】　前記多層配線基板の絶縁体は、アルミナ（Al_2O_3），ガラスセラミック，アルミニウムナイトライド（ＡｌＮ）およびムライトからなる群のうちの少なくとも１種を含む無機材料よりなることを特徴とする請求項１１記載の光導波装置。

【請求項２４】　前記多層配線基板の絶縁体は、ガラスエポキシ樹脂，ポリイミド，ＢＴ樹脂，ＰＰＥ（polyphenyl ether）樹脂，フェノール樹脂およびポリオレフィ

ン樹脂からなる群のうちの少なくとも１種を含む有機材料よりなることを特徴とする請求項１１記載の光導波装置。

【請求項２５】 第１の基板を支持基体として光導波路を形成する工程と、
前記第１の基板により支持された前記光導波路と第２の基板とを固着させる工程と、
前記第１の基板を除去することにより前記光導波路を前記第２の基板に転写する工程とを含むことを特徴とする光導波装置の製造方法。

【請求項２６】 前記光導波路と第２の基板とを固着させる工程を、接着剤を用いて行うようにしたことを特徴とする請求項２５記載の光導波装置の製造方法。

【請求項２７】 前記接着剤として光硬化性樹脂を用いることを特徴とする請求項２６記載の光導波装置の製造方法。

【請求項２８】 前記第１の基板として光透過性の材料よりなる基板を用いると共に、この第１の基板を通して光を照射することにより、前記光硬化性樹脂を硬化させることを特徴とする請求項２７記載の光導波装置の製造方法。

【請求項２９】 前記光導波路を形成する工程および前記光導波路と第２の基板とを固着する工程は、
コア層を形成する工程と、
このコア層を囲むようにして、クラッド層となる樹脂層を形成する工程と、
未硬化状態の前記樹脂層を前記接着剤として用いて、前記第１の基板により支持された前記光導波路と前記第２の基板とを接着する工程と、
前記樹脂層を硬化させて前記クラッド層を形成すると同時に、前記光導波路と前記第２の基板との固着を完了させる工程とを含むことを特徴とする請求項２６記載の光導波装置の製造方法。

【請求項３０】 前記光導波路を形成する工程は、
前記第１の基板と前記光導波路との間に、後工程において前記第１の基板を前記光導波路から分離することを可能とする基板分離層を形成する工程を含むと共に、
前記光導波路を第２の基板に転写する工程において、前記基板分離層を除去することにより前記第１の基板の除去を行うようにしたことを特徴とする請求項２５記載の光導波装置の製造方法。

【請求項３１】 前記基板分離層を、二酸化珪素（SiO_2）により形成することを特徴とする請求項３０記載の光導波装置の製造方法。

【請求項３２】 前記第１の基板として、所定の溶液により溶解可能な材料からなる基板を用いると共に、
前記光導波路を第２の基板に転写する工程において、前記第１の基板を熔解することによりこれを除去するようにしたことを特徴とする請求項２５記載の光導波装置の製造方法。

【請求項３３】 前記溶液は５体積％以下のフッ化水素（ＨＦ）溶液であり、前記溶解可能な材料は感光性ガラスであることを特徴とする請求項３２記載の光導波装置の製造方法。

【請求項３４】 前記第１の基板上に光導波路を形成する工程は、
互いに離間した複数の光導波路を形成する工程を含み、
前記光導波路と第２の基板とを固着させる工程は、
前記光導波路に、光硬化性樹脂よりなる接着層を介して前記第２の基板を接着させる工程と、
前記第１の基板を介して前記接着層に光を照射して、この接着層のうち、前記光導波路に対応する領域のみを選択的に露光して硬化させる工程と、
前記第２の基板上の未硬化の光硬化性樹脂を除去する工程とを含むことを特徴とする請求項２５記載の光導波装置の製造方法。

【請求項３５】 前記光導波路に第２の基板を接着させる工程の前に、更に、
前記第１の基板上の前記光導波路が形成されている領域以外の領域および前記各光導波路の側面に遮光膜を形成する工程を含み、この遮光膜をマスクとして選択的露光を行うことを特徴とする請求項３４記載の光導波装置の製造方法。

【請求項３６】 前記遮光膜を形成する工程は、
前記光導波路の前記第２の基板と固着される側の面に剥離層を形成する工程と、
前記第１の基板、前記光導波路および前記剥離層の露出面全体に遮光膜を形成する工程と、
前記剥離層を除去することにより、前記剥離層と接している前記遮光膜を選択的に除去する工程とを含むことを特徴とする請求項３５記載の光導波装置の製造方法。

【請求項３７】 更に、
前記第２の基板上に、電気信号を光信号に変換するための発光素子または光信号を電気信号に変換するための受光素子の少なくとも一方を形成する工程を含むことを特徴とする請求項２５記載の光導波装置の製造方法。

【請求項３８】 更に、
前記第２の基板上に、前記発光素子または前記受光素子の少なくとも一方との間で電気信号の授受を行うための集積回路を形成する工程を含むことを特徴とする請求項３７記載の光導波装置の製造方法。

【請求項３９】 前記第２の基板は、電気的配線が形成された電気配線基板であることを特徴とする請求項２５記載の光導波装置の製造方法。

【請求項４０】 更に、
前記第２の基板上に、電気信号を光信号に変換するための発光素子または光信号を電気信号に変換するための受光素子の少なくとも一方を形成する工程と、
前記第２の基板上に、前記発光素子または前記受光素子の少なくとも一方との間で電気信号の授受を行うための

集積回路を形成する工程とを含むことを特徴とする請求項３９記載の光導波装置の製造方法。

【請求項４１】　更に、
前記発光素子または前記受光素子の少なくとも一方、および前記集積回路を封止樹脂材料によって封止する工程を含むことを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項４２】　前記第１の基板を支持基体として光導波路を形成する工程は、
前記第１の基板上に前記第１の基板と前記光導波路とを分離可能な基板分離層を形成する工程と、
前記基板分離層の上に光導波路を形成する工程と、
前記光導波路の少なくとも一端部に傾斜面を形成する工程とを含むことを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項４３】　前記光導波路を形成する工程は、
前記基板分離層上に第１のクラッド層を形成する工程と、
前記第１のクラッド層上にコア層を形成する工程と、
前記コア層上に第２のクラッド層を形成する工程とを含むことを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項４４】　前記第２の基板として、アルミナ（Al_2O_3），ガラスセラミック，アルミニウムナイトライド（ＡｌＮ）およびムライトからなる群のうちの少なくとも１種の無機材料を含む多層配線基板を用いることを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項４５】　前記第２の基板として、ガラスエポキシ樹脂，ポリイミド，ＢＴ樹脂，ＰＰＥ（polyphenyl ether）樹脂，フェノール樹脂およびポリオレフィン樹脂からなる群のうちの少なくとも１種の有機材料を含む多層配線基板を用いることを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項４６】　前記第２の基板は、コア基板と、このコア基板の少なくとも一方の面に形成されると共に、電気的配線パターンが印刷された印刷基板とから構成されていることを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項４７】　前記第１および第２のクラッド層を形成する材料として、光の屈折率が前記コア層を形成する材料よりも小さいものを用いることを特徴とする請求項４３記載の光導波装置の製造方法。

【請求項４８】　前記第１および第２のクラッド層を形成する材料として、ポリイミド，エポキシ樹脂，アクリル樹脂，ポリオレフィン樹脂および合成ゴムからなる群のうちの少なくとも１種を主成分として含むものを用いることを特徴とする請求項４３記載の光導波装置の製造方法。

【請求項４９】　前記基板分離層を形成する材料として、二酸化シリコン（SiO_2）を用いることを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５０】　前記基板分離層を形成する材料として、エッチング可能な金属材料を用いることを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５１】　前記光導波路の少なくとも一端部に傾斜面を形成する工程は、
前記光導波路上にフォトレジストを塗布し、このフォトレジストに露光および現像処理を施して所望のフォトレジストパターンを形成する工程と、
前記フォトレジストパターンのエッジ領域を傾斜させる工程と、
前記フォトレジストパターンをマスクとして、前記光導波路の前記フォトレジストパターンのエッジ領域から露出している部分を異方性エッチングして、前記光導波路の端部をテーパ状の傾斜面とする工程と、
前記フォトレジストパターンを除去する工程とを含むことを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５２】　前記光導波路の少なくとも一端部に傾斜面を形成する工程は、
前記光導波路上に金属膜を蒸着形成する工程と、
前記金属膜上にフォトレジストを塗布し、このフォトレジストに露光および現像処理を施して所望のフォトレジストパターンを形成する工程と、
前記フォトレジストパターンをマスクとして前記金属膜をエッチングして前記金属膜を所望のパターンに形成する工程と、
前記金属膜をマスクとして前記光導波路層の所定の領域に所定の角度からレーザ光を照射して前記光導波路を切断することにより前記傾斜面を形成する工程と、
前記金属膜をエッチングにより除去し、被加工物全体を洗浄する工程とを含むことを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５３】　前記光導波路の少なくとも一端部に傾斜面を形成する工程は、
先端部に傾斜面を有する加熱工具を加熱し、この加熱工具の先端部を前記光導波路に押入して光導波路を溶融することにより、前記光導波路に前記傾斜面を形成する工程と、
前記加熱工具を除去したのちに、前記光導波路の溶融部に生じた加工屑を研磨加工によって除去する工程とを含むことを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５４】　前記光導波路の少なくとも一端部に傾斜面を形成する工程は、
前記第１の基板を所定の角度で切断する工程と、
前記第１の基板の前記切断により形成された端面を研磨して前記光導波路の端部を傾斜面とする工程とを含むことを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５５】　前記第１の基板として、光を透過させる光透過性の材料からなる基板を用いると共に、
前記光導波路に第２の基板を固着させる工程は、
前記第２の基板上の所定の位置に、光の照射によって硬化する光硬化性樹脂からなる接着層を形成する工程と、
前記第１の基板に形成された光導波路に前記第２の基板の接着層を密着させる工程と、
前記第１の基板の裏面から前記第２の基板に向けて光を照射して、前記接着層を硬化させる工程とを含むことを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項５６】　前記光導波路に第２の基板を固着させる工程は、
前記第２の基板上の所定の位置に熱硬化性樹脂からなる接着層を形成する工程と、
前記第１の基板に形成された光導波路に前記第２の基板の接着層を密着させる工程と、
前記第１の基板および第２の基板全体を加熱して前記接着層を硬化させる工程とを含むことを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項５７】　前記第１の基板を除去することにより前記光導波路を前記第２の基板に転写する工程において、接着された前記第１の基板と前記第２の基板との間に溶剤を供給して前記基板分離層を除去し、前記第１の基板を前記光導波路から分離するようにしたことを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５８】　前記第１の基板を除去することにより前記光導波路を前記第２の基板に転写する工程において、接着された前記第１の基板と前記第２の基板との間に溶剤を供給して前記基板分離層と前記光導波路との界面を分離するようにしたことを特徴とする請求項４２記載の光導波装置の製造方法。

【請求項５９】　前記発光素子または受光素子の少なくとも一方および前記集積回路は、接続電極を有しており、
前記発光素子または受光素子の少なくとも一方を形成する工程および前記集積回路を形成する工程において、前記発光素子または受光素子の少なくとも一方および前記集積回路を、前記接続電極を用いてフリップチップボンディング法により前記第２の基板に実装するようにしたことを特徴とする請求項４０記載の光導波装置の製造方法。

【請求項６０】　前記発光素子または受光素子の少なくとも一方を形成する工程および前記集積回路を形成する工程において、前記光導波路を、前記発光素子または受光素子の少なくとも一方および前記集積回路と前記第２の基板との間に介在するスペーサとして利用するようにしたことを特徴とする請求項５９記載の光導波装置の製造方法。

【請求項６１】　金属細線の先端に形成された球状部を前記発光素子または受光素子の少なくとも一方あるいは前記集積回路の電極に圧着したのち、前記球状部と前記金属細線との間を引き離すようにして切断することにより前記接続電極を形成するようにしたことを特徴とする請求項５９記載の光導波装置の製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、内部を光信号が伝搬する光導波路を備えた光導波装置およびその製造方法に係り、特に、超高速信号処理回路や並列型デジタル信号処理回路等の信号処理回路における光信号の伝送や、光通信、光リンクあるいは光ファイバチャンネル等の光伝送用送受信モジュールの光接続に用いて好適な光導波装置およびその製造方法に関する。

【０００２】

【従来の技術】近年、セルラー電話などに用いられる無線通信技術、ＩＳＤＮ（Integrated Services Digital Network ）などに用いられる有線通信技術、あるいはパーソナルコンピュータ（Personal Computer ；ＰＣ）など情報処理装置の処理能力が飛躍的に向上したことや、ＡＶ（Audiovisual ）機器がデジタル化されたことなどにより、あらゆるメディアを情報通信ネットワークを介して送受信する動きが進展している。また、インターネットを始め、ＬＡＮ（Local Area Network）やＷＡＮ（Wide Area Network ）といった情報通信ネットワークが業務用および個人用に普及しつつある。これらのことから、将来、家庭内でＰＣを中心に家電製品やＡＶ機器でネットワークを構成し、電話回線、ＣＡＴＶ（Cable Televisionあるいは Community Antenna Television）、地上波テレビジョンあるいは衛星放送／衛星通信などの情報伝達手段によって情報を自由にやりとりする環境が実現すると考えられる。

【０００３】このような情報伝達手段によって数Ｍ～十数Ｍｂｐｓという速い速度で取り扱われる画像データなどを自由にやり取りするためには、例えば、１０Ｍ～１Ｇｂｐｓ程度の情報伝送速度が望まれる。光通信・伝送技術は、そのような情報伝送速度を実現することが可能である。例えば、海底に敷設された光ケーブルのように、１０ｋｍ～１００ｋｍを越えるいわゆる幹線系通信網では、その低損失性や経済性などの観点から、光通信・伝送技術が広く普及している。

【０００４】一方、機器内のボード間あるいはボード内のチップ間など、比較的短距離間の情報伝達手段としては、主に、ツイステッドペアーケーブルや同軸ケーブルなどの有線通信・伝送手段が用いられている。近年になって、光ファイバチャンネルや光データリンク等の光伝送を用いる技術の普及が始まっているものの、現行では、光通信・伝送手段は有線通信・伝送手段に置き換わる程の普及には至っていない。この理由としては、コスト対効果の問題が挙げられる。具体的には、例えば、光通信の性能（例えば、伝送速度や伝送品質）を維持する

ために、光通信装置を構成する発光素子および受光素子と光ファイバとの間に精密な位置合わせ技術が必要であること、洩れ光対策、電磁的干渉への配慮、あるいはノイズ対策なども必要であること、および結果的に装置が複雑且つ高価になってしまうこと等の点が挙げられる。

【０００５】一方、ＩＣ（Integrated Circuit；集積回路）やＬＳＩ（Large Scale Integration ；大規模集積回路）における技術の進歩により、それらの動作速度や集積規模が向上し、例えばマイクロプロセッサの高性能化やメモリチップの大容量化が急速に達成されている。また、ネットワークにより接続されたＰＣが取り扱う情報量は急速に増加している。従って、信号処理クロックの周波数の上昇や並列度の上昇、およびメモリへのアクセス時間の高速化などに対応しなければならないという課題も存在する。このような状況下において、半導体チップの微細化やそれに伴うトランジスタのゲート長の縮小、駆動能力の向上などにより、半導体チップの内部では動作速度の高速化が図られている。しかしながら、メモリへのアクセス回路やマルチＭＰＵ（Microprocessor Unit ）構成の処理装置などにおいては、半導体装置のパッケージなどのような実装時に必要となる部分の寄生容量成分が大きく、半導体チップの外部に接続される電気的配線においては高速の信号伝送動作が難しくなっている。また、電気的配線への高速信号の印加は、スパイク状の電流変化あるいは電圧変化の原因となると共に、ＥＭＩ（Electromagnetic Interference）／ＥＭＣ（Electromagnetic Compatibility ）などの電磁干渉ノイズ、反射ノイズおよびクロストークノイズの原因となる。

【０００６】そこで、配線基板上の半導体チップ間など短距離の信号伝送経路においても、高速信号の伝送を行うためには、光による伝送を行うこと、特に光導波路を伝送路とした光伝送・通信システムを用いることが望ましいと考えられる。光により信号伝送を行う場合には、配線のＣＲ（Ｃ：配線の静電容量、Ｒ：配線の抵抗）時定数による信号遅延を解消でき、かつ電磁的ノイズの影響を避けることができるので、高速の信号の授受が可能となる。従って、光通信・伝送の通信性能を有線通信・伝送の通信性能と同等に維持すると共に、コストの低減を実現することにより、一般需要者向けの機器の分野においても短距離間の光通信・伝送システムを普及させる必要がある。

【０００７】光通信・伝送の通信性能を有線通信・伝送の通信性能と同等に維持するためには、例えば光導波路の光伝搬損失が小さいことが要求される。この条件を満たす光伝搬損失の小さい材料としては、石英系の材料がある。石英は、既に光ファイバで実証されているように、光透過性が極めて良好であり、石英により光導波路を作製した場合には０．１ｄＢ／ｃｍ以下の低損失化が達成されている。

【０００８】図３２は、従来の光導波装置の一構成例を表すものである（特開昭６２－２０４２０８号公報参照）。この光導波装置は、絶縁層５０６によって各配線間が絶縁された薄膜多層配線５０５が形成された平坦なシリコン基板５０１上に、石英よりなる光導波路５０２およびＬＳＩ５０４を備えている。また、光導波路５０２の各端部領域の上方には、受光素子５０３および発光素子（図示せず）がそれぞれ形成され、その近傍に配置されたＬＳＩ５０４とそれぞれ電気的に接続されている。この光導波装置では、図示しない発光素子から出射した光信号が、光導波路５０２の内部を伝搬して、端面５０２ａで反射され、受光素子５０３に入射するようになっている。

【０００９】このような構成を有する光導波装置の製造方法としては、薄膜多層配線５０５が形成されたシリコン基板５０１上に光導波路５０２を形成したのち、例えばＲＩＥ（Reactive Ion Etching；反応性イオンエッチング）などの異方性エッチングにより光導波路５０２の端面５０２ａをシリコン基板５０１の表面に対して略４５°となるように加工し、更に、シリコン基板５０１上に受光素子５０３、発光素子およびＬＳＩ５０４を実装するという方法が知られている。

【００１０】

【発明が解決しようとする課題】しかしながら、上述した光導波装置の製造方法では、石英よりなる光導波路５０２をシリコン基板５０１上に形成するようにしているため、光導波路５０２の形成技術として薄膜技術を用いる必要があった。薄膜技術を用いた光導波路５０２の形成は、寸法精度に優れる反面、厚さ数μｍ以上の膜の形成および加工が困難であるという不利益が存在する。

【００１１】また、たとえ光により信号を高速に伝送できたとしても、電力供給や比較的低速の各種のコントロール信号などの伝送は、依然として電気的配線（電気信号）により行う必要がある。そのため、シリコン基板５０１上に電気的配線としての薄膜多層配線５０５を形成することが必須であるが、この電気的配線形成領域が通常の配線基板サイズ（数十ｃｍ角）やモジュールサイズ（数ｃｍ角）になると、コストがかかりすぎ、実現性に乏しいという問題があった。

【００１２】この問題を解決するために、電気部品を搭載可能な印刷配線基板上に光導波路を形成することが考えられる。ところが、このような厚膜工程により製作させる配線基板の表面には、例えばめっき法により形成された金属の厚膜などが配設されており、凹凸が大きい。そのため、このような印刷配線基板上に光導波路を形成すると、基板表面の凹凸形状が光導波路の形状に影響を及ぼしてしまい、光導波路の光伝搬損失の増大や寸法精度の低下につながってしまうという問題があった。

【００１３】更に、配線基板上に光導波路を形成する場合には、ウェットエッチングや洗浄などを行う際に、酸

・アルカリ溶液や有機溶剤などに基板全体を浸す工程が必要となるので、基板に損傷を与えるおそれがあるという問題があった。また、ドライエッチング時や、高温熱処理時に、基板に損傷を与えるおそれもある。従って、基板として厚膜工程による電気配線基板を用いることは困難であり、例えば高耐熱性などの特性を有している高価な基板を使用する必要があった。

【００１４】本発明はかかる問題点に鑑みてなされたもので、その第１の目的は、支持基体の種類にかかわらず、高い光伝搬特性を担保し得る光導波路を有する光導波装置およびその製造方法を提供することにある。

【００１５】本発明の第２の目的は、光導波路が安価に形成されると共に、製造コストの低減化を図ることができる光導波装置およびその製造方法を提供することにある。

【００１６】また、本発明の第３の目的は、電気的配線のみでは実現が困難であった更なる高速の信号の伝送を可能にすると共に、伝送信号の耐電磁ノイズ性を向上させることのできる光導波装置およびその製造方法を提供することにある。

【００１７】

【課題を解決するための手段】本発明による光導波装置は、基板と、内部を光信号が伝搬しうるように予め別途形成されると共に、基板上に配置されて、固着された光導波路とを備えたものである。

【００１８】本発明による光導波装置の製造方法は、第１の基板を支持基体として光導波路を形成する工程と、第１の基板により支持された光導波路と第２の基板とを固着させる工程と、第１の基板を除去することにより光導波路を第２の基板に転写する工程とを含むものである。

【００１９】本発明による光導波装置では、予め別途形成された光導波路が基板上に配置されており、この光導波路の内部を光信号が伝搬する。

【００２０】本発明による光導波装置の製造方法では、第１の基板を支持基体として形成された光導波路と第２の基板とが固着されたのち、第１の基板が除去されることにより光導波路が第２の基板に転写される。

【００２１】

【発明の実施の形態】以下、本発明の実施の形態について図面を参照して詳細に説明する。

【００２２】（第１の実施の形態）まず、図１を参照して、本発明の第１の実施の形態に係る光導波装置の構成について説明する。

【００２３】図１は、本実施の形態に係る光導波装置１の断面構成を表すものである。この光導波装置１は、多層配線基板２と、多層配線基板２に接着層６を介して接着された光導波路１１と、光導波路１１をスペーサとして間に挟んで多層配線基板２上に実装された受光素子２１、ＩＣチップ２５，３５および発光素子３１とを備えている。ここで、多層配線基板２が、本発明の「基板」および「第２の基板」の一具体例に対応している。また、ＩＣチップ２５，３５が、本発明の「集積回路」の一具体例に対応している。

【００２４】多層配線基板２は、複数の電気配線３が絶縁体４を介して積層された電気配線基板である。電気配線３は、ＩＣチップ２５，３５、受光素子２１および発光素子３１に電力を供給する機能を有すると共に、ＩＣチップ２５，３５と受光素子２１および発光素子３１との間で例えば低速コントロール信号の授受を行ったり、外部との間で信号の授受を行う機能を有している。すなわち、電気配線３は、多層配線基板２上に受光素子２１、発光素子３１およびＩＣチップ２５，３５を実装するための実装用パターン配線である。具体的には、受光素子２１、発光素子３１およびＩＣチップ２５，３５に電力を供給するためのグラウンドラインを含む各種電源配線パターン、コントロール用信号を供給するための配線を含むＩＣチップ２５，３５と受光素子２１および発光素子３１とを結合するための配線などが形成されている。

【００２５】多層配線基板２としては、例えば、絶縁体４がアルミナ（Al_2O_3）、低温焼成ガラスセラミック、ガラスセラミック、アルミニウムナイトライド（ＡｌＮ）、ムライトなどの無機材料からなるセラミック多層配線基板が使用されている。また、絶縁体４がＦＲ－４などのガラスエポキシ樹脂からなるガラスエポキシ多層配線基板や、通常のガラスエポキシ配線基板上に例えば感光性エポキシ樹脂などを用いたフォトリソグラフィ技術で高密度パターン形成を可能にした、所謂ビルドアップ多層配線基板、絶縁体４にポリイミドフィルムなどを用いたフレキシブル多層配線基板、あるいはＢＴ樹脂、ＰＰＥ（polyphenyl ether）樹脂、フェノール樹脂、ポリオレフィン樹脂（例えばデュポン社製のテフロン（商標登録））などの有機材料を用いた多層配線基板が使用される場合もある。その他、例えば誘電体材料からなるコア基板上に、電気的配線パターンが高密度に印刷された印刷基板が配設されてなる、所謂プリント配線基板を使用することもできる。

【００２６】接着層６は、光導波路１１と多層配線基板２との間に介在しており、例えば、ガラスエポキシ樹脂などの光硬化性樹脂または熱硬化性樹脂により構成されている。また、その厚さは、例えば１０μｍ程度である。この接着層６は、光導波路１１と多層配線基板２とを接着させる役割の他に、多層配線基板表面の凸凹を平坦化する役割も果たしている。

【００２７】光導波路１１は、例えば、コア層５４と、コア層５４を囲むようにして形成された上部クラッド層５３および下部クラッド層５５とにより構成されている。この光導波路１１は、例えば両端部に、多層配線基板２の表面となす外角が鋭角（ここでは、略４５°）で

あるような傾斜面１１ａ，１１ｂを有している。なお、光導波路１１の多層配線基板２の表面となす外角とは、光導波路１１の光伝搬方向に沿った断面が閉じた図形であると考えた場合におけるこの図形の外角のことを意味する。ここで、上部クラッド層５３が本発明の「第１のクラッド層」の一具体例に、下部クラッド層５５が本発明の「第２のクラッド層」の一具体例にそれぞれ対応している。また、傾斜面１１ａ，１１ｂが、本発明の「光反射部」の一具体例に対応している。

【００２８】傾斜面１１ａ，１１ｂは、上述したように多層配線基板２の表面となす外角が略４５゜であり、光導波路１１の外部から多層配線基板２の主面と直交する方向に入射する光信号を反射させて光導波路１１内に導入すると共に、光導波路１１内を伝搬してきた光信号を反射させて多層配線基板２の主面に直交する方向に導出する機能を有している。

【００２９】上部クラッド層５３および下部クラッド層５５は、例えば屈折率が１．５２程度のビスフェノールを主材とするエポキシ樹脂により構成されており、厚さが例えば２０μｍである。また、コア層５４は、上部クラッド層５３および下部クラッド層５５の構成材料よりも屈折率の大きな材料、例えば屈折率が１．５４程度のエポキシ樹脂により構成されている。コア層５４の厚さは例えば２０μｍであり、幅は例えば６０μｍである。なお、上部クラッド層５３、コア層５４および下部クラッド層５５は、コア層５４の屈折率が上部クラッド層５３および下部クラッド層５５の屈折率よりも大きいという条件を満たすものであれば、他の材料、例えば、ポリイミド、ポリメチルメタクリレート（ＰＭＭＡ；Polymethyl Methacrylate ）などのアクリル樹脂、ポリエチレンやポリスチレンなどのポリオレフィン樹脂、あるいは合成ゴムにより構成されていてもよい。

【００３０】受光素子２１は、その入射面に光導波路１１から入射される光信号を電気信号に変換して、多層配線基板２に形成された電気配線３に出力するものであり、その一例としてはフォトダイオードが挙げられる。ここで、受光素子２１の入射面は、光導波路１１の傾斜面１１ａと対向する位置に、多層配線基板２の主面と直交するように設けられている。

【００３１】発光素子３１は、多層配線基板２の電気配線３を通じて発光素子３１に入力される電気信号を光信号に変換して、その光信号を出射面から光導波路１１の傾斜面１１ｂに対して出射するものであり、その一例としては発光ダイオード（ＬＥＤ；Light Emitting Diode）が挙げられる。なお、発光素子３１の出射面は、光導波路１１の傾斜面１１ｂと対向する位置に、多層配線基板２の主面と直交するように設けられている。

【００３２】ＩＣチップ２５，３５には、例えば信号処理回路やメモリ回路などの電子回路が集積されており、多層配線基板２の電気配線３を通じて電源が供給される。また、このＩＣチップ２５，３５は、受光素子２１および発光素子３１と電気配線３によって電気的に接続されており、受光素子２１および発光素子３１との間で電気信号の授受を行う機能を有している。

【００３３】受光素子２１、発光素子３１およびＩＣチップ２５，３５には、例えば電極パッド（図示せず）がそれぞれ設けられている。これらの電極パッドは、例えば鉛（Ｐｂ）および錫（Ｓｎ）を主成分とするはんだ（Ｐｂ－Ｓｎはんだ）よりなる球状のバンプ（突起）ＢＰと接している。すなわち、受光素子２１、発光素子３１およびＩＣチップ２５，３５は、光導波路１１を間に挟んで配置されると共に、バンプＢＰによって多層配線基板２上の電気配線３と電気的に接続されている。このバンプＢＰが、本発明の「接続電極」の一具体例に対応している。なお、バンプＢＰとしては、金（Ａｕ）よりなるボールバンプ、あるいは銅（Ｃｕ）などの導電性よりなる球状体（ボールコア）にはんだがコーティングされたものを用いることもできる。

【００３４】次に、この光導波装置１の作用について説明する。

【００３５】この光導波装置１では、例えば多層配線基板２の電気配線３から供給された電力によって、受光素子２１、発光素子３１およびＩＣチップ２５，３５が動作可能な状態となる。この状態で、ＩＣチップ３５から発光素子３１に電気信号が出力されると、発光素子３１は、電気信号を光信号に変換して、出射面から光信号を出射する。出射された光信号は、傾斜面１１ｂに入射し、傾斜面１１ｂで反射して光導波路１１内に導入される。そののち、この光信号は、光導波路１１内を伝搬し、傾斜面１１ａで反射して受光素子２１の入射面に入射する。受光素子２１に入射した光信号は、電気信号に変換されてＩＣチップ２５に入力される。このようにして、ＩＣチップ３５とＩＣチップ２５との間で光信号が高速伝送される。また、低速コントロール信号などの比較的低速で伝送してもよい信号は、多層配線基板２の電気配線３によって電気信号のまま伝送される。ここで、光信号の伝送速度が本発明の「第１の速度」の一具体例に、電気信号の伝送速度が本発明の「第２の速度」の一具体例にそれぞれ対応している。

【００３６】このように本実施の形態に係る光導波装置では、ＩＣチップ２５，３５、受光素子２１および発光素子３１への電力の供給およびＩＣチップ３５やＩＣチップ２５をコントロールする比較的低速で伝送してもよい信号は、多層配線基板２の電気配線３によって行うことができ、ＩＣチップ３５とＩＣチップ２５との間で高速に伝送すべき信号は、発光素子３１、光導波路１１および受光素子２１によって光信号により伝送することができる。よって、電気配線３のＣＲ時定数による信号の遅延の問題を解消することができる。また、電磁輻射ノイズの問題や波形の乱れに起因する誤動作の問題を解消

することもできる。

【００３７】また、本実施の形態に係る光導波装置では、ＩＣチップ２５，３５、受光素子２１および発光素子３１は、多層配線基板２上に、光導波路１１およびバンプＢＰを介在させて実装されており、光導波路１１はＩＣチップ２５，３５、受光素子２１および発光素子３１を支えると共に、バンプＢＰを配置するためのスペースを確保するスペーサの役割をも果たしている。このため、ＩＣチップ２５，３５、受光素子２１および発光素子３１は、多層配線基板２上に安定に固定され得る。また、光導波路１１によって、ＩＣチップ２５，３５、受光素子２１および発光素子３１と電気配線３との距離を所定の値に維持することができる。

【００３８】次に、図２ないし図１２を参照して、本実施の形態に係る光導波装置の製造方法について説明する。なお、図２ないし図４は、それぞれ一製造工程を表す斜視図である。図５において、（Ａ）は一製造工程を表す斜視図であり、（Ｂ）は（Ａ）のＸＢ－ＸＢ線に沿った断面構造を表している。図６、図７および図１２は、それぞれ一製造工程を表す断面図である。図８、図９および図１１において、（Ａ）はそれぞれ一製造工程を一部破断して表す斜視図であり、（Ｂ）は（Ａ）のVIIIB－VIIIB線（図８）、IXB－IXB線（図９）、およびXIB－XIB線（図１１）に沿った断面構造をそれぞれ表している。

【００３９】まず、図２に示したように、例えば石英ガラス、鉛ガラス、ソーダガラス、あるいは雲母（マイカ）などのような紫外域から可視域にかけての光を比較的よく透過する材料（光透過性材料）よりなる平坦性に優れた透明基板５１を用意し、この透明基板５１上に、例えばプラズマＣＶＤ（Chemical Vapor Deposition ）法、熱ＣＶＤ法、または光ＣＶＤ法等の方法により、例えば厚さ５００ｎｍの二酸化シリコン（SiO_2）よりなる基板分離層５２を形成する。この基板分離層５２は、透明基板５１を光導波路１１から分離するためのものである。その詳細は後述する。なお、二酸化シリコンは、紫外域から可視域の光に対してほぼ透明の材料である。次に、基板分離層５２上に、例えばスピンコート法により例えばエポキシ樹脂を２０μｍ程度の厚さになるように塗布したのち、加熱処理を行なって樹脂を固化させ、例えば屈折率が１．５２である上部クラッド層５３を形成する。

【００４０】次に、図３に示したように、上部クラッド層５３上に、例えば上部クラッド層５３の形成方法と同様の方法により、上部クラッド層５３の構成材料よりも屈折率の高い材料（例えばエポキシ樹脂）を用いて、例えば屈折率が１．５４であり、厚さ３０μｍ程度であるコア層５４′を形成する。

【００４１】次に、図４に示したように、所定のパターンのフォトレジスト膜（図示せず）を形成し、このフォトレジスト膜をマスクとして、例えばＲＩＥを行う。これにより、コア層５４′は、平面形状が帯状である、互いに離間した複数のコア層５４となる。

【００４２】次に、図５に示したように、例えば、透明基板５１の全面に、上部クラッド層５３の形成方法と同様の方法により、上部クラッド層５３と同一の材料を用いて厚さが２０μｍ程度の下部クラッド層５５を形成する。

【００４３】なお、上部クラッド層５３、コア層５４および下部クラッド層５５は、それらの各下地層上に光硬化性樹脂を塗布したのち、この光硬化性樹脂に対して光照射を行って樹脂を硬化させることにより形成するようにしてもよい。

【００４４】次に、図６に示したように、下部クラッド層５５上に、例えば厚さ数十μｍ程度のフォトレジスト膜５６を形成する。次に、フォトレジスト膜５６に所定の露光処理および現像処理を施してフォトレジスト膜５６を所定のパターンに加工したのち、このパターンニングされたフォトレジスト膜５６を例えばガラス転移温度以上の温度で加熱処理する。これにより、フォトレジスト膜５６のエッジ部分が流動して、傾斜面（図６のＥ部）が形成される。

【００４５】次に、図７に示したように、フォトレジスト膜５６をマスクとして、例えばＲＩＥ装置あるいはＥＣＲ（Electro Cyclotron Resonance ；電子サイクロトロン共鳴）装置を用いて光導波路１１の異方性エッチングを行う。これにより、光導波路１１の両端部に、フォトレジスト膜５６の傾斜面に対応する形状、すなわち、透明基板５１の表面となす外角が略１３５°であるような傾斜面１１ａ，１１ｂが形成される。そののち、フォトレジスト膜５６を除去する。

【００４６】次に、図８に示したように、例えば多層配線基板２を用意し、この多層配線基板２上の所望の領域に、例えば、スピンコート法、ディップコート法、スプレー法または印刷法等の方法により、ガラスエポキシ樹脂などの光硬化性樹脂よりなる厚さ１０μｍ程度の接着層６を形成する。

【００４７】次に、図９に示したように、光導波路１１が形成された透明基板５１の天地を反転し、位置合わせを行いながら接着層６が形成されている多層配線基板２に光導波路１１を密着させる。続いて、透明基板５１側の光導波路１１と多層配線基板２とを密着させた状態で、透明基板５１側から多層配線基板２側に向かって光Ｌを照射する。これにより、接着層６を構成する光硬化性樹脂が硬化し、多層配線基板２は光導波路１１の所望の位置に固着される。このとき、大きな光量で短時間光Ｌを照射すると、光導波路１１にひずみが生じ、光伝搬損失が大きくなってしまう。そこで、光Ｌの照射は、比較的小さな光量で時間をかけて行う。例えば、超高圧水銀ランプ（波長；ｇ線（４３６ｎｍ）中心）を用いる場

合には、１０ｍＷ／ｃｍ² の出力で５分間行う。

【００４８】図１０は、本実施の形態においてコア層５４、上部クラッド層５３および下部クラッド層５５として用いたエポキシ樹脂（厚さ１ｍｍ）の光透過率を表すグラフである。縦軸は光透過率（単位；％）を示し、横軸は光の波長（単位；ｎｍ）を示している。図１０からも分かるように、このエポキシ樹脂は、３５０ｎｍ程度より長い波長の近紫外領域および可視領域の光を９０％程度透過させる光透過性樹脂である。また、上記したように、透明基板５１および基板分離層５２は、紫外域から可視域にかけて十分な透明性を有する。従って、例えば超高圧水銀ランプから発せられる光Ｌは、透明基板５１、基板分離層５２および光導波路１１を透過して接着層６まで十分に到達し、例えばガラスエポキシ樹脂よりなる接着層６は完全に硬化する。

【００４９】次に、光導波路１１に多層配線基板２が固着されている状態で、透明基板５１と多層配線基板２とを、例えば薄いフッ化水素（ＨＦ）溶液、または緩衝フッ化水素（ＢＨＦ；Buffered　ＨＦ）溶液に浸す。これにより、図１１に示したように、透明基板５１と光導波路１１との間に形成された基板分離層５２が溶解除去され、基板分離層５２上の透明基板５１が光導波路１１から分離された状態（リフトオフ）となり、光導波路１１が多層配線基板２に転写される。そののち、光導波路１１が転写された多層配線基板２を水により予洗し、洗浄して、乾燥させる。

【００５０】次に、図１２に示したように、受光素子２１、発光素子３１およびＩＣチップ２５，３５の図示しない電極パッドに、それぞれバンプＢＰを形成する。具体的には、例えば、金細線の先端に形成された金よりなる球状部を受光素子２１、発光素子３１およびＩＣチップ２５，３５の電極パッドにそれぞれ圧着し、球状部から細線を引き離すようにして球状部と細線との間を切断し、バンプＢＰを形成する。そののち、受光素子２１、発光素子３１およびＩＣチップ２５，３５をフリップチップボンディング法によって多層配線基板２に実装し、光導波路１１にダメージを与えない程度のリフローを行う。ここで、フリップチップボンディング法とは、バンプＢＰと多層配線基板２に設けられたバンプＢＰに対向する電極（配線）とを位置合わせして密着させ、熱および圧力を加えてこれらを接合する方法をいう。なお、フリップチップボンディング法を用いずに、例えば印刷法などによって多層配線基板２上の所望の位置にはんだペーストを供給したのち、受光素子２１などを実装し、リフローを行ってもよい。また、受光素子２１、発光素子３１およびＩＣチップ２５，３５の他に、例えばチップ型抵抗器、コンデンサまたはインダクタなどの他の素子を実装することも可能である。

【００５１】最後に、図示はしないが、実装した受光素子２１、発光素子３１およびＩＣチップ２５，３５と多層配線基板２との間に、例えば毛管現象を利用して封止用樹脂（例えば、エポキシ樹脂）を導入し、受光素子２１、発光素子３１およびＩＣチップ２５，３５を封止する。これにより、受光素子２１、発光素子３１およびＩＣチップ２５，３５と電気配線３との接続信頼性が向上する。

【００５２】このように本実施の形態に係る光導波装置の製造方法では、光導波路１１を、平坦性に優れた透明基板５１上に予め形成したのち、多層配線基板２に転写するようにしたので、表面の凹凸が大きい多層配線基板２を支持基体として用いる場合であっても、光伝搬損失の少ない光導波路１１を有する光導波装置１を作製することが可能である。

【００５３】また、本実施の形態によれば、多層配線基板２として比較的低コストのセラミック多層配線基板やプリント配線基板を使用し、この多層配線基板２上に、ＩＣチップ２５，３５、受光素子２１および発光素子３１などの部品を実装するようにしたので、部品を容易に実装することができる。更に、シリコン基板上に薄膜技術によって電気配線層を形成して、その上に部品を実装するという従来の方法に比べて、光による信号伝送、電気による信号伝送および電力供給を同時に行うことができる光導波装置１をより安価に製造することができる。

【００５４】また、本実施の形態によれば、光導波路１１を形成する薄膜プロセスと多層配線基板２を形成する厚膜プロセスとに分け、薄膜プロセスにより形成された光導波路１１を、多層配線基板２に転写するようにしたので、円板状の基板以外の基板の上には膜形成が困難であるとされているスピンコート法などを用いなくても、多角形などの他の形状の基板上に簡単に光導波路１１を形成することができる。この結果、光導波路１１の支持基体としての基板（ここでは、多層配線基板２）の形状や材料などの選択の自由度が広がり、製造コスト低減を図ることができる。

【００５５】また、本実施の形態のように多層配線基板２とは別に透明基板５１に予め光導波路１１を形成しておき、光導波路１１を転写するプロセスを用いると共に、光導波路１１の断面形状（特に、幅）を大きく形成するした場合には、光導波路１１に対するＩＣチップ２５，３５、発光素子２１および受光素子３１の位置合わせが容易になり、この点でも製造コストを低減することが可能になる。

【００５６】なお、本実施の形態では、光導波路１１をスペーサとして、光導波路１１と接するようにＩＣチップ２５，３５、発光素子２１および受光素子３１を実装するようにしたが、上述したように、実装時にリフローを行う際に光導波路１１にダメージを与えないように注意を払う必要がある。従って、バンプＢＰをスペーサとして、光導波路１１とＩＣチップ２５，３５、発光素子２１および受光素子３１とが離間するように実装しても

よい。その場合には、バンプＢＰによって、ＩＣチップ２５，３５、発光素子２１および受光素子３１と電気配線３との距離が所定の値に維持されると共に、信頼性の高い電気的接続が可能になる。

【００５７】（第２の実施の形態）本実施の形態は、光導波装置の製造方法に関するものである。その対象となる光導波装置は、各光導波路間が分離されている点を除き、上記第１の実施の形態と同様である。以下、図１ないし図５および図１３ないし図２０を参照して、本実施の形態の光導波装置の製造方法について説明する。図１３ないし図２０は、それぞれ、各製造工程を一部破断して表す斜視図である。なお、第１の実施の形態と同一の構成要素には同一の符号を付し、ここではその詳細な説明を省略する。

【００５８】本実施の形態に係る製造方法では、まず、第１の実施の形態の図２～図５に示した工程と同様にして、透明基板５１上に基板分離層５２および光導波路１１を形成する。

【００５９】次に、図１３に示したように、光導波路１１上に、例えばプラズマＣＶＤ（Chemical Vapor Deposition ）法、熱ＣＶＤ法、または光ＣＶＤ法等の方法により、例えば厚さ５００ｎｍの二酸化シリコン（SiO_2）よりなる剥離層９１を形成する。この剥離層９１は、後述する遮光膜９２（図１５参照）を選択的に除去するためのものである。続いて、第１の実施の形態と同様のリソグラフィ技術を用いて、光導波路１１の両端部に、透明基板５１の表面となす外角が略１３５°であるような傾斜面１１ａ，１１ｂ（ここでは、図示せず）を形成する。

【００６０】次に、図１４に示したように、例えば、図示しない所定のパターンのフォトレジスト膜を形成し、このフォトレジスト膜をマスクとして、レーザ加工、あるいは例えば酸素（Ｏ）プラズマを用いたプラズマエッチングやイオンビームエッチングやパウダーを用いたエッチング（パウダービームエッチング）などのエッチング加工を行うことにより、剥離層９１、光導波路１１および基板分離層５２を選択的に除去する。ここでは、光導波路１１の下面（すなわち、上部クラッド層５３と基板分離層５２との界面）に至るまで確実に除去する必要があるため、基板分離層５２が露出するまでレーザ照射あるいはエッチングを行うようにする。これにより、光導波路１１およびその上に形成された剥離層９１は、互いに離間した複数の光導波路１１′および剥離層９１′へと分割される。なお、除去する部分が直線により構成された単純なパターンである場合には、ダイシングなどにより除去するようにしてもよい。

【００６１】次に、図１５に示したように、透明基板５１、光導波路１１および剥離層９１の露出面全体に、例えば蒸着法あるいはスパッタ法により、例えば厚さ１００ｎｍのクロム（Ｃｒ）よりなる遮光膜９２を形成する。なお、遮光膜９２は、後述する接着層６を露光して硬化させる際に、選択的に遮光するためのものである。ちなみに、遮光膜９２の構成材料としては、光を遮断可能な材料であればクロム以外の材料を用いてもよい。具体的には、アルミニウムやタンタル（Ｔａ）等を用いてもよい。

【００６２】次に、図１６に示したように、例えば、希フッ酸溶液を用いて二酸化シリコンよりなる剥離層９１′を溶解除去することにより、剥離層９１′と接している（すなわち、光導波路１１上の）遮光膜９２を選択的に除去する（リフトオフ法）。これにより、光導波路１１の上面のみが露出した状態となる。

【００６３】次に、図１７に示したように、多層配線基板２を用意し、この多層配線基板２上の所望の領域に、例えば、スピンコート法、ディップコート法、スプレー法または印刷法等の方法により、ガラスエポキシ樹脂などの光硬化性樹脂よりなる厚さ１０μｍ程度の接着層６を形成する。

【００６４】次に、図１８に示したように、例えば、第１の実施の形態の図９に示した工程と同様にして、光導波路１１′が形成された透明基板５１を天地反転させて、多層配線基板２を光導波路１１′に圧着したのち、透明基板５１の側から多層配線基板２の方向に向けて光Ｌを照射する。ここでは、遮光膜９２が、光導波路１１′と接着層６との界面には形成されておらず、光導波路１１′の側面および透明基板５１の多層配線基板２との対向面のうちの光導波路１１′が形成されていない領域のみに形成されている。従って、透明基板５１側から照射された光Ｌは、光導波路１１′が形成されている領域Ａにおいてのみ接着層６まで到達し、その他の領域Ｂにおいては遮光膜９２により遮断され、接着層６まで到達しない。その結果、接着層６のうち、光導波路１１′の下部の領域Ａのみが硬化し、その他の領域Ｂは未硬化のままとなる。そして、この硬化した接着層６により、多層配線基板２は光導波路１１′に固着される。

【００６５】次に、図１９に示したように、接着層６のうちの、遮光膜９２により光Ｌが照射されずに未硬化のままの領域Ｂの樹脂を、例えばアセトンあるいはエタノールにより選択的に溶解除去する。

【００６６】次に、図２０に示したように、例えば、酸性溶液（例えば塩酸溶液）を用いてクロムよりなる遮光膜９２を溶解したのち、例えば第１の実施の形態の図１１に示した工程の方法と同様の方法で基板分離層５２を溶解除去することにより、光導波路１１′を多層配線基板２に転写する。以下の工程は、第１の実施の形態と同一である。

【００６７】このように本実施の形態では、予め透明基板５１の上に、互いに分離された複数の光導波路１１′を形成すると共に、遮光膜９２を用いて多層配線基板２の全面に形成した未硬化状態の接着層６と光導波路１

１′とを密着させ、光導波路１１′形成領域の下側部分の接着層６のみを選択的に硬化させるようにしたので、透明基板５１上の複数の光導波路１１′を多層配線基板２に良好に転写することができる。すなわち、多層配線基板２上に、互いに離間して形成され、かつ、光伝搬損失の少ない複数の光導波路１１′を配設することができる。

【００６８】また、ここでは、平面形状が帯状の複数の光導波路１１′を形成する場合について説明したが、本実施の形態の製造方法を用いれば、透明基板５１上に形成された任意の平面形状（例えば、L字状、U字状あるいは円弧状など）の光導波路１１′を多層配線基板２に転写することができ、例えば多層配線基板２の電極形成領域などのように光導波路を転写したくない領域には転写せずに、必要な箇所にのみ光導波路を転写することができる。

【００６９】（第３の実施の形態）本発明の第３の実施の形態は、光導波路の製造方法に関するものであり、その対象としての光導波装置の構造自体は、図１に示したものと同様である。本実施の形態に係る光導波装置の製造方法は、光導波路１１の傾斜面１１ａ，１１ｂの形成方法が異なる点を除き、他は第１の実施の形態と同様である。以下、図２１ないし図２３を参照して説明する。なお、これらの図において、第１の実施の形態と同一の構成要素には同一の符号を付し、ここではその詳細な説明を省略する。

【００７０】本実施の形態の傾斜面の形成方法では、まず、図２１に示したように、透明基板５１上に基板分離層５２を介して上部クラッド層５３、コア層５４および下部クラッド層５５からなる光導波路１１を形成する。次に、下部クラッド層５５上に、例えばアルミニウムよりなる金属膜６０を蒸着法により形成する。次に、金属膜６０上にフォトレジスト膜５６を形成したのち、フォトレジスト膜５６に所定の露光および現像処理を施して所望のフォトレジストパターンを形成すると共に、フォトレジスト膜５６を例えばガラス転移温度以上の温度で加熱処理することにより、フォトレジスト膜５６のエッジ部分に傾斜面Eを形成する。

【００７１】次に、図２２に示したように、フォトレジスト膜５６をマスクとして金属膜６０をエッチングして、金属膜６０の両端部をフォトレジスト膜５６の傾斜面Eに対応した形状の傾斜面Fとする。

【００７２】次に、図２２に示したように、金属膜６０をマスクとして所望の角度から例えばCO_2ガスレーザなどのレーザ光ＬＢの照射を行い、光導波路１１を切断する。このとき、光導波路１１の端部となる切断面が、光導波路１１の長手方向（光伝搬方向）に対して略４５°に傾斜した傾斜面１１ａ，１１ｂとなるようにする。それ以降の工程は、第１の実施の形態と同様である。

【００７３】このように本実施の形態によれば、光導波路１１の端部の傾斜面１１ａ，１１ｂの形成を、レーザ光ＬＢを所定の角度から照射して光導波路１１を切断することにより行うため、薄膜形成プロセスのみにより傾斜面１１ａ，１１ｂを形成する場合よりも、精度良く、また簡単に形成することができる。

【００７４】（第４の実施の形態）本発明の第４の実施の形態は、光導波路の製造方法に関するものであり、その対象としての光導波装置の構造自体は、図１に示したものと同様である。本実施の形態に係る光導波装置の製造方法は、光導波路１１の傾斜面１１ａ，１１ｂの形成方法が異なる点を除き、他は第１の実施の形態と同様である。以下、図２４ないし図２７を参照して説明する。なお、これらの図において、第１の実施の形態と同一の構成要素には同一の符号を付し、ここではその詳細な説明を省略する。

【００７５】本実施の形態では、まず、図２４に示したように、第１の実施の形態と同様のプロセスで、透明基板５１上に基板分離層５２を形成し、この上に上部クラッド層５３、コア層５４および下部クラッド層５５からなる光導波路１１を形成する。

【００７６】次に、図２５に示したように、先端面Ｔｂに対して略４５°に傾斜する２つの面取り状斜面Ｔａを有するヒートツールＴを準備し、このヒートツールＴを光導波路１１を構成する上部クラッド層５３、コア層５４および下部クラッド層５５を構成する樹脂素材のガラス転移温度以上の温度に加熱する。続いて、加熱されたヒートツールＴの先端を多層配線基板２に押し付けて、光導波路１１を溶融する。必要であれば、多層配線基板２の主面に沿った方向にヒートツールＴを移動させるようにしてもよい。

【００７７】次に、図２６に示したように、ヒートツールＴを多層配線基板２から取り去ると、光導波路１１の溶融された領域には、凹部Ｈが形成され、凹部Ｈの内面が、光導波路１１の長手方向に対して略４５°に傾斜した傾斜面１１ａ，１１ｂとなる。なお、凹部Ｈの周囲には、熱変形によりスカム（加工屑）Ｋが発生する。このため、基板５１のスカムＫの形成面を、例えば、グラインド基板７１の研磨面に押し付け、軽く研磨する。この研磨によって、図２７に示したように、凹部Ｈの周囲のスカムＫが除去されると共に、光導波路１１の上面は平坦化される。最後に洗浄・乾燥処理を行うことによって光導波路１１の傾斜面１１ａ，１１ｂが完成する。それ以降の工程は、第１の実施の形態と同様である。

【００７８】このように本実施の形態によれば、光導波路１１の傾斜面１１ａ，１１ｂをヒートツールＴの斜面Ｔａによって形成するようにしているため、これらの傾斜面１１ａ，１１ｂをヒートツールＴの斜面Ｔａと同一の傾斜角度に形成することができ、傾斜面１１ａ，１１ｂの精度を高めることができる。

【００７９】（第５の実施の形態）本発明の第５の実施

の形態は、光導波路の製造方法に関するものであり、その対象としての光導波装置の構造自体は、図１に示したものと同様である。本実施の形態に係る光導波装置の製造方法は、光導波路１１の傾斜面１１ａ，１１ｂの形成方法が異なる点を除き、他は第１の実施の形態と同様である。以下、図２８ないし図３０を参照して説明する。なお、これらの図において、第１の実施の形態と同一の構成要素には同一の符号を付し、ここではその詳細な説明を省略する。

【００８０】本実施の形態では、まず、図２８に示したように、第１の実施の形態と同様のプロセスで、透明基板５１上に基板分離層５２を形成し、この上に上部クラッド層５３、コア層５４および下部クラッド層５５からなる光導波路１１を形成する。

【００８１】次に、図２９に示したように、光導波路１１が形成された透明基板５１を、例えばダイシングソーなどの切断手段によって光導波路１１の長手方向（光伝搬方向）に対して４５゜の角度で切断する（図２９のＦ部）。

【００８２】次に、図３０に示したように、切断された透明基板５１をグラインド基板８１に対して４５゜の角度で傾斜させて、透明基板５１の切断面をグラインド基板８１の研磨面に接触させ研磨する。これによって、光導波路１１の一端部に光導波路１１の長手方向に対して４５゜で傾斜する傾斜面１１ａを形成することができる。以下の工程は、第１の実施の形態とほぼ同様である。

【００８３】このように本実施の形態によれば、光導波路１１の傾斜面１１ａを機械的に研磨するようにしているため、傾斜面１１ａの精度を高めることができる。なお、この傾斜面１１ａの形成方法は、透明基板５１の主面に沿って複数配列された光導波路１１の端面加工を一括して行うことができるので好都合である。

【００８４】（第６の実施の形態）本発明の第６の実施の形態は、一芯光ファイバを通じてデータの送受信を行う光送受信モジュールとして構成された光導波装置に関するものである。図３１は、本実施の形態に係る光導波装置の断面構造を表すものである。なお、第１の実施の形態と同一の構成要素には同一の符号を付し、ここではその説明を省略する。

【００８５】この光導波装置は、多層配線基板２（例えばガラスエポキシ多層配線基板）と、多層配線基板２上に形成された光導波路１１と、多層配線基板２上にバンプＢＰを介して実装された送信用の発光素子としての端面発光型のレーザダイオード１０１およびＩＣチップ１０２と、多層配線基板２に埋め込まれた受光素子１０３と、多層配線基板２上の受光素子１０３と対向する位置に配設された一芯光ファイバ２０１とを備えている。また、多層配線基板２上には、レーザダイオード１０１の駆動回路や、トランスインピーダンスアンプなどの受信回路に代表される他の回路や部品を搭載することが可能である（図示せず）。

【００８６】光導波路１１は、第１の実施の形態の方法により多層配線基板２上に転写され、樹脂からなるパッシベーション膜を兼ねた接着層６によって、多層配線基板２に固着されている。光導波路１１の一端には、多層配線基板２の表面となす外角が略４５゜であり、反射面として機能する傾斜面１１ａが形成されている。光導波路１１は、傾斜面１１ａの位置が受光素子１０３の中央部にくるように位置決めされている。受光素子１０３は、受光する光の波長に対して感度を有している。

【００８７】一芯光ファイバ２０１は、内部に形成されたファイバコア層２０２と、ファイバコア層２０２の外周に形成されたファイバクラッド層２０３とから構成され、一端部が受光素子１０３から所定の距離だけ離間するように設けられている。ファイバコア層２０２の直径は、傾斜面１１ａの大きさに比べて十分に大きくなっている。

【００８８】この光導波装置では、レーザダイオード１０１から出力された光信号は、光導波路１１に入力され、光導波路１１を伝搬して、傾斜面１１ａで反射して出射光L_{out}として一芯光ファイバ２０１に効率良く導入される。また、一芯光ファイバ２０１から出力される入射光L_{in}は、光導波路１１の傾斜面１１ａを含む多層配線基板２の広い領域に照射されるが、傾斜面１１ａでけられる光量はわずかであり、入射光L_{in}のほとんどは受光素子１０３の受光部１０３ａに吸収されるので、効率の良い受信を行うことが可能である。

【００８９】このように本実施の形態によれば、一芯光ファイバ２０１と、受光素子１０３やレーザダイオード１０１との間の配置の自由度が大きくなり、低コストで、かつ性能の良い光送受信モジュールとすることができる。

【００９０】以上、いくつかの実施の形態を挙げて本発明を説明したが、本発明は上記各実施の形態に限定されるものではなく、種々変形可能である。例えば、上記実施の形態では、接着層６の上に光導波路１１の下部クラッド層５５を接着させた構成としたが、接着層６を下部クラッド層５５と同じ機能を果たす材料により構成すれば、下部クラッド層５５が接着層６を兼ねている構成とすることができる。また、上部クラッド層５３についても、多層配線基板２に光導波路１１を転写する際に、空気をクラッド層として利用するようにして、上部クラッド層５３を形成しない構成とすることも可能である。これらの結果、光導波路１１の形成プロセスを簡略化することができ、製造コストを低減させることができる。

【００９１】また、上記第１の実施の形態では、接着層６の形成材料として光硬化性樹脂を用いた場合について説明したが、このほか、熱硬化性樹脂を用いることもできる。この場合には、透明基板５１に光導波路１１を形

成したのち、多層配線基板２上の所望の領域に、例えば印刷法によりエポキシ樹脂あるいはアクリル樹脂などの熱硬化性樹脂からなる接着層６を形成し、透明基板５１上の光導波路１１に多層配線基板２を密着させた状態で、加熱する。これにより、接着層６を構成する熱硬化性樹脂が硬化して、多層配線基板２は光導波路１１に固着される。この場合、光導波路形成用の基板（本発明における第１の基板）は、光透過性のものでなくてもよい。但し、転写の際の位置合わせを容易にするには、透明の基板を用いることが好ましい。

【００９２】また、上記実施の形態では、基板分離層５２の形成材料として二酸化シリコンを用いると共に、この基板分離層５２を薄いフッ化水素溶液、あるいは緩衝フッ化水素溶液に浸して溶解除去するようにしたが、アセトンもしくはイソプロピルアルコールなどの有機溶剤をシャワー状に吹き付けて基板分離層５２を溶解し、基板分離層５２と光導波路１１とをこれらの界面で分離させることも可能である。更に、基板分離層５２をアルミニウム（Ａｌ）や銅などのウェットエッチング可能な金属材料により形成し、この基板分離層５２を薄い塩酸（ＨＣｌ）、水酸化ナトリウム（ＮａＯＨ）あるいは水酸化カリウム（ＫＯＨ）などの溶液を用いて溶解除去するようにしてもよい。

【００９３】また、上記実施の形態では、透明基板５１として石英ガラスなどの光透過性材料を用いたが、光透過性を有し、かつ溶解可能な感光性ガラスなどの材料を用いるようにしてもよい。この場合には、感光性ガラスは、例えば５体積%以下の希フッ化水素溶液に浸すことにより溶解されるので、基板分離層５２は不要となる。

【００９４】また、上記実施の形態では、光反射部（傾斜面１１ａ，１１ｂ）を光導波路１１の端面全体に設けるようにしたが、コア層５４の端面のみに設けるようにしてもよい。

【００９５】

【発明の効果】以上説明したように請求項１ないし請求項２４のいずれか１項に記載の光導波装置によれば、光導波路を予め別途形成すると共に、この光導波路を基板上に配置して、固定するようにしたので、基板上に直接光導波路が形成される場合とは異なり、光導波路を支持する基板の種類や形状に影響されずに一定の特性を担保することが可能になる。従って、任意の基板を用いて構成することができるという効果を奏する。

【００９６】特に、請求項８ないし請求項２４のいずれか１項に記載の光導波装置によれば、電気的配線が形成された基板上に、光導波路、発光素子または受光素子の少なくとも一方、および集積回路を備えるように構成したので、高速に伝送すべき信号は光信号として高速伝送する一方、比較的低速で伝送してもよい信号は電気信号として伝送するというように、用途や目的に応じて伝送形態を使い分けることも可能である。そのため、電気的配線により伝送する場合に問題となる信号の伝搬遅延が解消されると共に、電磁的ノイズの影響を受けるおそれが少なくなり、その結果、波形の乱れに起因する誤動作を効果的に防止することができる。よって、この光導波装置を用いれば、電気的配線のみでは実現困難であった高速の信号授受が可能となり、システムやネットワークの性能を飛躍的に高めることも可能となる。

【００９７】また、請求項２５ないし請求項６１のいずれか１項に記載の光導波装置の製造方法によれば、第１の基板上に形成された光導波路を第２の基板に転写するようにしたので、従来において耐熱性に優れた高価な基板上にのみ形成可能であった光導波路を、任意の材料および形状の、より廉価な基板上に形成することができるという効果を奏する。更に、第１の基板として平坦性に優れた基板を用いることにより、光伝搬損失の少ない光導波路を作製することができる。

【００９８】特に、請求項３４ないし請求項３６のいずれか１項に記載の光導波装置の製造方法によれば、第１の基板上に互いに離間した複数の光導波路を形成し、これらの光導波路に接着層を介して第２の基板を接着させたのち、接着層のうち、光導波路が形成されている領域に対応する領域のみを選択的に露光して硬化させるようにしたので、任意の基板の所望の領域に、互いに分離された複数の光導波路を転写することができる。

【００９９】また、請求項３９ないし請求項６１のいずれか１項に記載の光導波装置の製造方法によれば、第２の基板として、厚膜工程によって予め形成された電気配線基板を用いるようにしたので、薄膜技術を用いて基板上に電気的配線を形成したのち、その上に光導波路を形成する場合よりも、容易かつ安価に製造することができる。

【０１００】特に、請求項４８記載の光導波装置の製造方法によれば、第１および第２のクラッド層を形成する材料として、石英よりも安価な、ポリイミド，エポキシ樹脂，アクリル樹脂，ポリオレフィン樹脂または合成ゴムの少なくとも１種を含むものを用いるようにしたので、光導波路の材料コストの低減化を図ることができる。

【０１０１】また、請求項５２記載の光導波装置の製造方法によれば、光導波路の少なくとも一端部の傾斜面の形成を、レーザ光を所定の角度から照射して光導波路を切断することにより行うようにしたので、薄膜形成プロセスのみにより形成する場合よりも、精度良く、また簡単に形成することができる。

【０１０２】また、請求項５３記載の光導波装置の製造方法によれば、先端部に所定の角度の傾斜面を有する加熱工具を加熱して光導波路に押入することにより光導波路の少なくとも一端面を傾斜面に加工するようにしたので、光導波路の傾斜面を加熱工具の傾斜面と同一の傾斜角度に形成することができ、その精度を高めることがで

きる。

【０１０３】また、請求項５４記載の光導波装置の製造方法によれば、光導波路が形成された第１の基板を所定の角度で切断したのち、第１の基板の切断により形成された端面を研磨して光導波路の傾斜面とするようにしたので、傾斜面の精度を高めることができる。

【０１０４】また、請求項６０記載の光導波装置によれば、光導波路を、発光素子または受光素子の少なくとも一方および集積回路と第２の基板との間に介在するスペーサとして利用するようにしたので、発光素子または受光素子の少なくとも一方および集積回路を第２の基板上に安定に固定することができる。

【図面の簡単な説明】

【図１】本発明の第１の実施の形態に係る光導波装置の構成を表す断面図である。

【図２】本発明の第１の実施の形態に係る光導波装置の一製造工程を説明するための斜視図である。

【図３】図２に続く製造工程を説明するための斜視図である。

【図４】図３に続く製造工程を説明するための斜視図である。

【図５】（Ａ）は図４に続く製造工程を説明するための一部破断した斜視図であり、（Ｂ）は（Ａ）のＸＢ－ＸＢ線に沿った断面図である。

【図６】図５に続く製造工程を説明するための断面図である。

【図７】図６に続く製造工程を説明するための断面図である。

【図８】（Ａ）は図７に続く製造工程を説明するための一部破断した斜視図であり、（Ｂ）は（Ａ）のVIIIＢ－VIIIＢ線に沿った断面図である。

【図９】（Ａ）は図８に続く製造工程を説明するための一部破断した斜視図であり、（Ｂ）は（Ａ）のIXＢ－IXＢ線に沿った断面図である。

【図１０】本発明の第１の実施の形態において用いたエポキシ樹脂の光透過率と光の波長との関係を表す特性図である。

【図１１】（Ａ）は図９に続く製造工程を説明するための一部破断した斜視図であり、（Ｂ）は（Ａ）のXIＢ－XIＢ線に沿った断面図である。

【図１２】図１１に続く製造工程を説明するための断面図である。

【図１３】本発明の第２の実施の形態に係る光導波装置の一製造工程を説明するための一部断面した斜視図である。

【図１４】図１３に続く製造工程を説明するための一部破断した斜視図である。

【図１５】図１４に続く製造工程を説明するための一部破断した斜視図である。

【図１６】図１５に続く製造工程を説明するための一部破断した斜視図である。

【図１７】図１６に続く製造工程を説明するための一部破断した斜視図である。

【図１８】図１７に続く製造工程を説明するための一部破断した斜視図である。

【図１９】図１８に続く製造工程を説明するための一部破断した斜視図である。

【図２０】図１９に続く製造工程を説明するための一部破断した斜視図である。

【図２１】本発明の第３の実施の形態に係る光導波装置の一製造工程を説明するための断面図である。

【図２２】図２１に続く製造工程を説明するための断面図である。

【図２３】図２２に続く製造工程を説明するための断面図である。

【図２４】本発明の第４の実施の形態に係る光導波装置の一製造工程を説明するための断面図である。

【図２５】図２４に続く製造工程を説明するための断面図である。

【図２６】図２５に続く製造工程を説明するための断面図である。

【図２７】図２６に続く製造工程を説明するための断面図である。

【図２８】本発明の第５の実施の形態に係る光導波装置の一製造工程を説明するための断面図である。

【図２９】図２８に続く製造工程を説明するための断面図である。

【図３０】図２９に続く製造工程を説明するための断面図である。

【図３１】本発明の第６の実施の形態に係る光導波装置の構成を表す断面図である。

【図３２】従来の光導波装置の一構成例を表す断面図である。

【符号の説明】

１…光導波装置、２…多層配線基板、３…電気配線、４…絶縁体、６…接着層、１１，１１′…光導波路、１１ａ，１１ｂ…傾斜面、２１…受光素子、２５，３５…ＩＣチップ、３１…発光素子、５１…透明基板、５２…基板分離層、５３…上部クラッド層、５４…コア層、５５…下部クラッド層、５６…フォトレジスト膜、９１，９１′…剥離層、９２…遮光膜、ＢＰ…バンプ、Ｌ…光、ＬＢ…レーザ光

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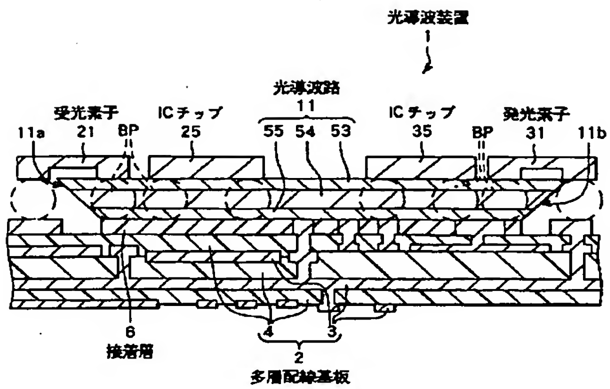

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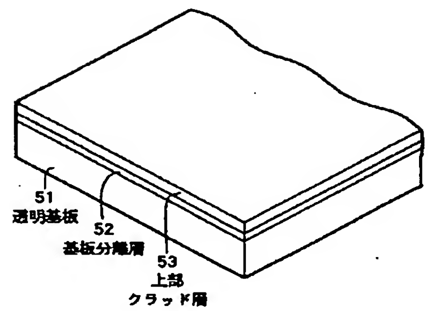

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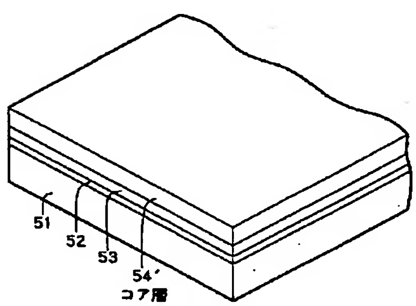

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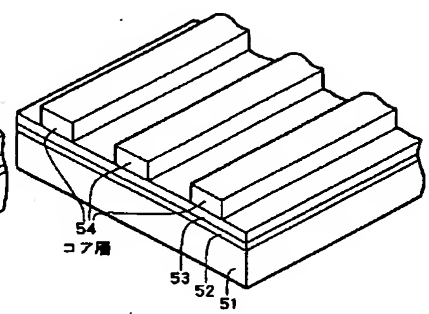

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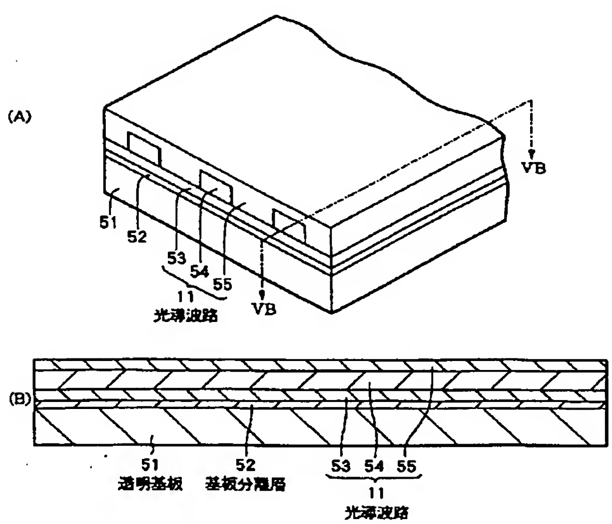

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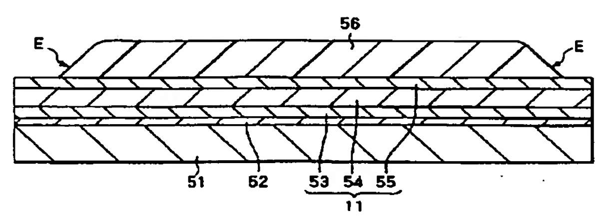

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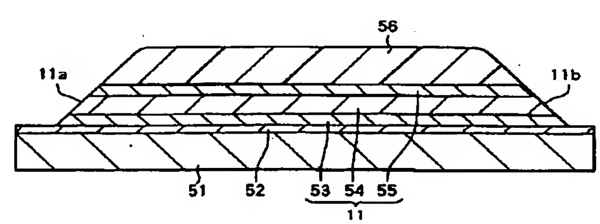

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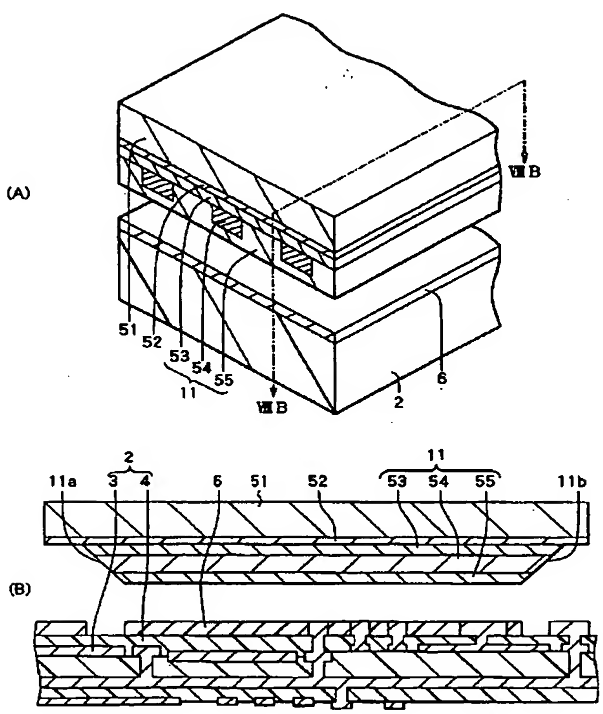

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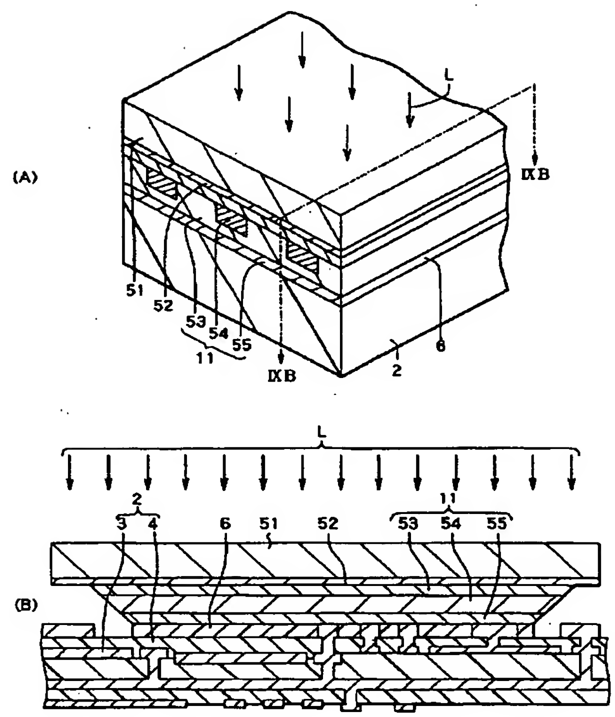

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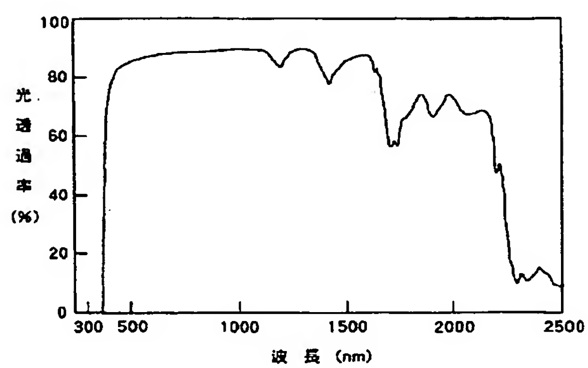

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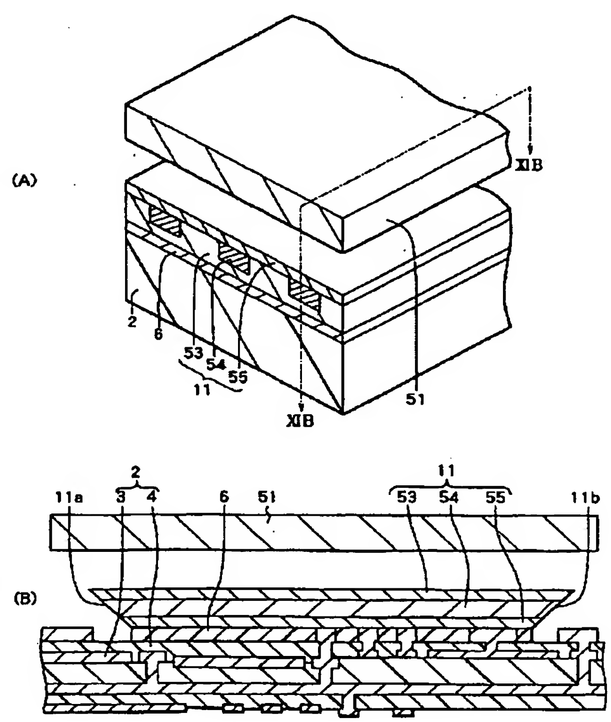

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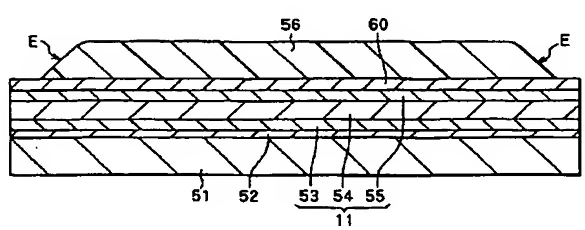

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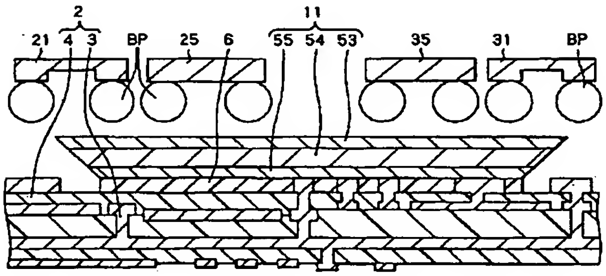

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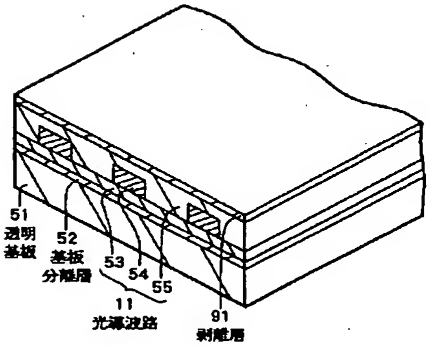

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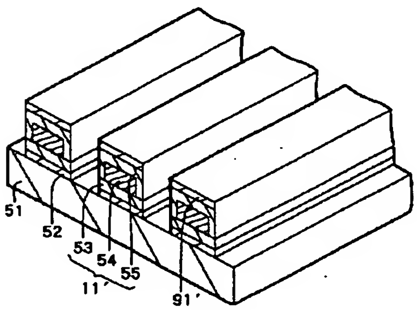

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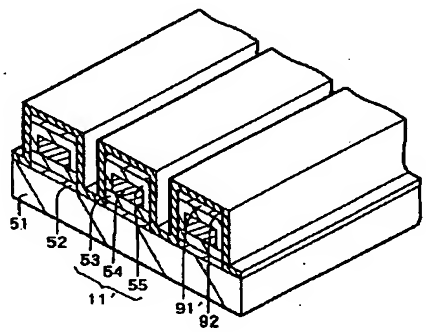

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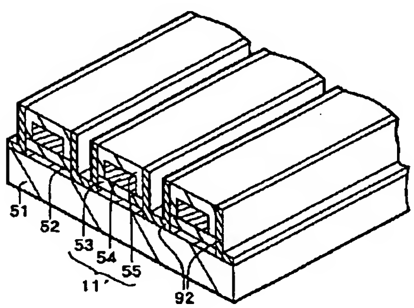

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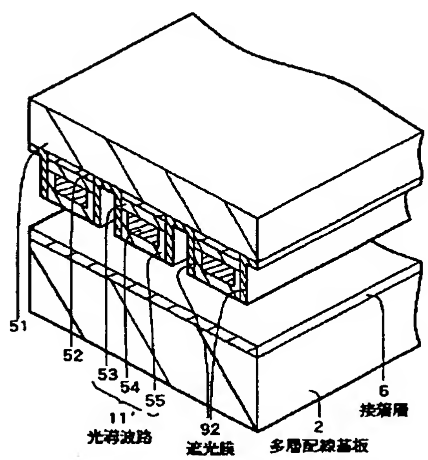

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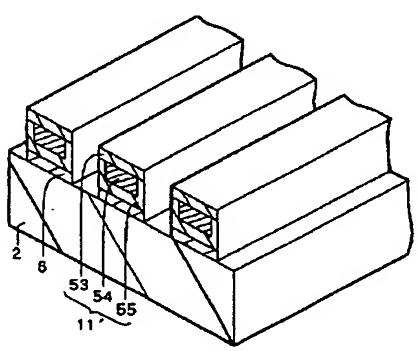

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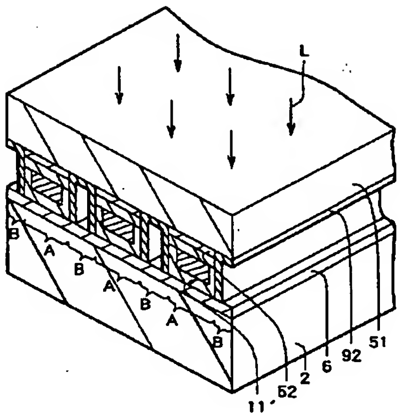

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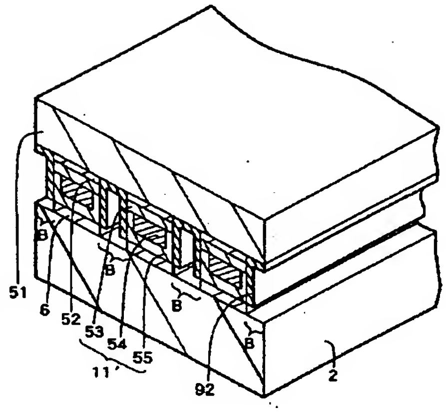

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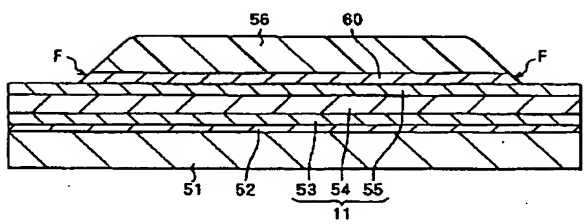

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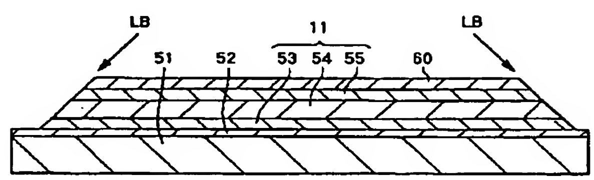

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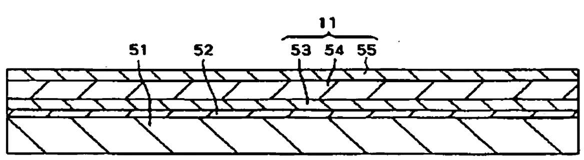

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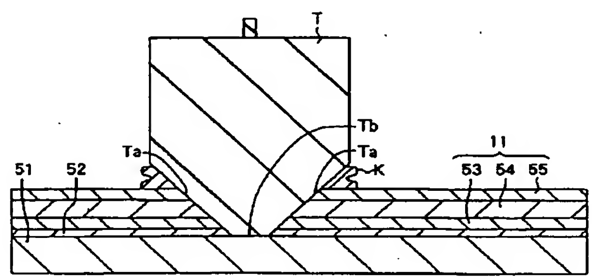

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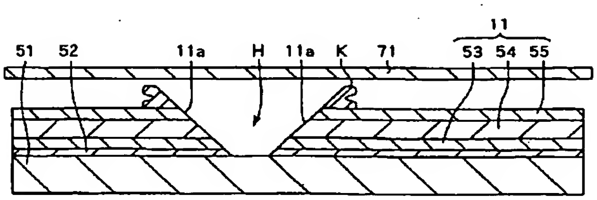

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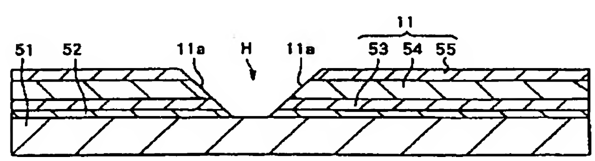

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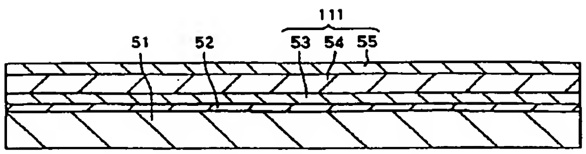

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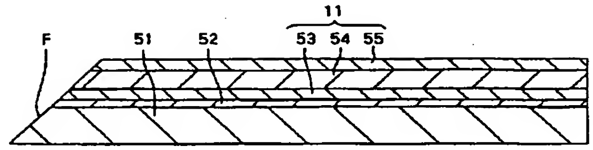

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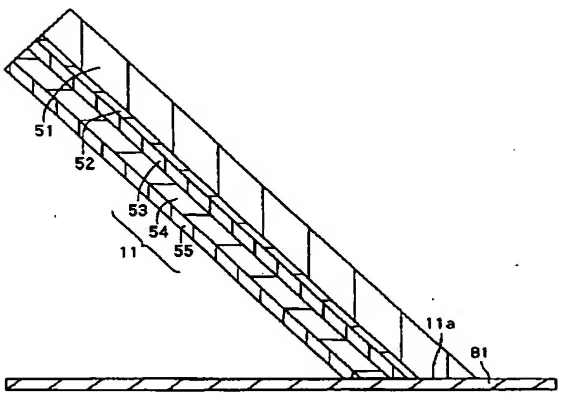

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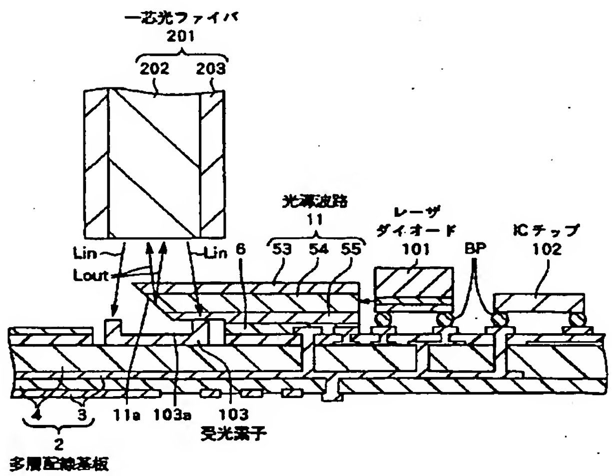

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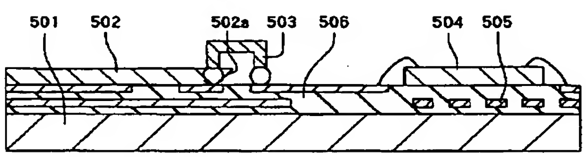

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PA21 PA24 QA04 QA05 QA07
TA31 TA43
5F073 AB15 AB28 BA01 FA30

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